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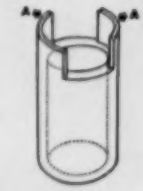

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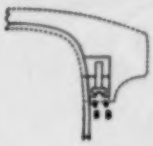
Fig. 2
Closed Barreloc Tube

Fig. 3
Barreloc Before Tightening



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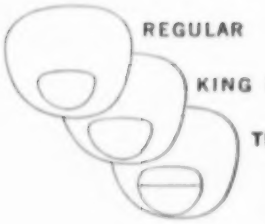

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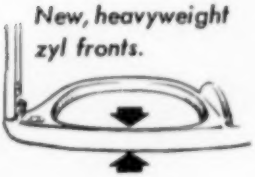

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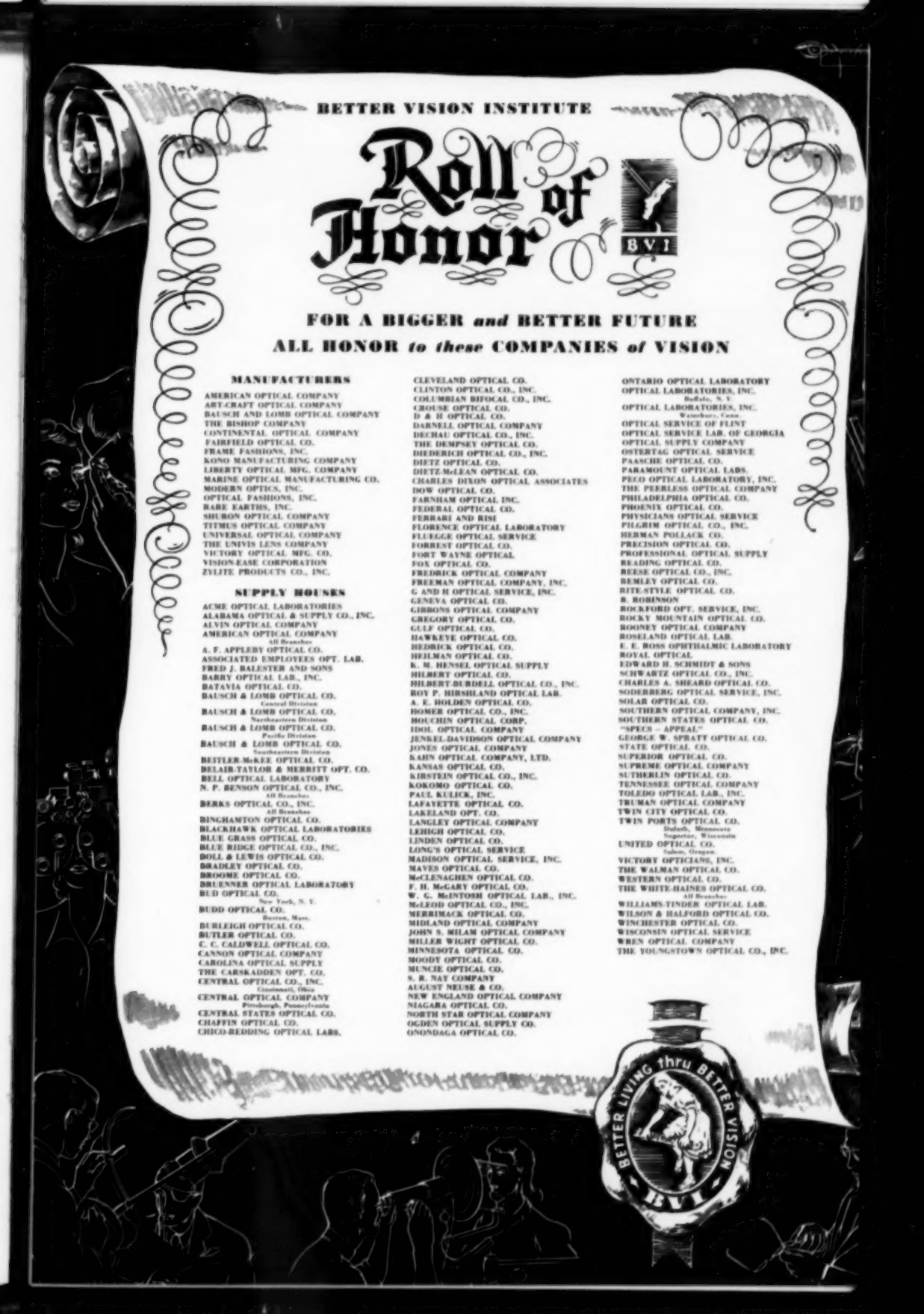

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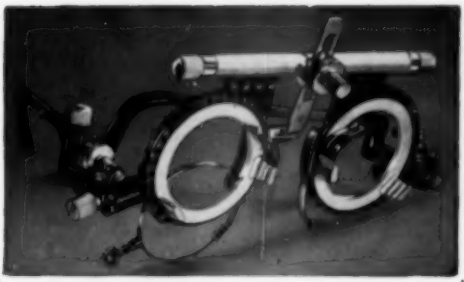

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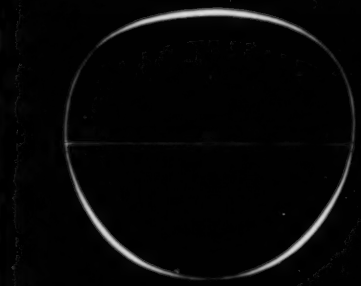

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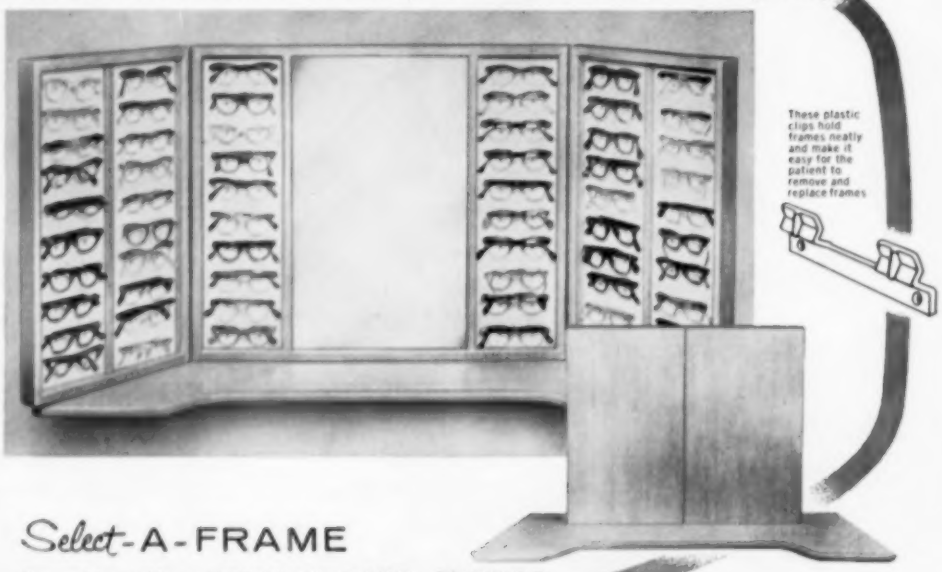

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Vol. 32 June, 1955 No. 6

AN EVALUATION OF THE VISUAL STATUS AND ACADEMIC ACHIEVEMENT OF A SELECTED GROUP OF ELEMENTARY SCHOOL CHILDREN OVER A PERIOD OF SEVEN YEARS*

Howard Haines†‡§
School of Optometry, The Ohio State University
Columbus, Ohio

At the beginning of the academic year, 1945-46, a testing program was initiated in a suburban elementary school for the purpose of assisting the teachers to enrich their understanding of the progress made by their respective children in achievement and intellectual development. This testing program evolved into a longitudinal study when it was found to be feasible to evaluate the children at regular intervals academically, intellectually, and visually.

These children are attending a typical suburban school in a good average community. A large percentage of the fathers are in professional and managerial positions, others are engaged in small private business units, skilled, semi-skilled, and unskilled activities.

This report is concerned with two phases of the study: visual maturation, and visual maturation in relation to academic achievement. Complete data were available on 37 of the 38 children who are still in the study (1953-54).

MEASURES

Tests of achievement in reading and arithmetic and tests of intellectual ability, group and individual were administered to the children at regular intervals as they were progressing through the grades.

About half of the group was examined visually in the first grade,

*Read before the annual meeting of the American Academy of Optometry, Section on Orthoptics, Toronto, Ontario, Canada, December 12, 1954. For publication in the June, 1955, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist, M.Sc., D.O.S., Member of faculty, Fellow, American Academy of Optometry.

‡Thelma Tyler, M.A., School Psychologist, Worthington Public Schools, Worthington, Ohio, and Wilda Rosebrook, Ph.D., Bureau of Special and Adult Education, The Ohio State University, Columbus, Ohio, assisted the author in the preparation of this report.

§The statistical treatment of the data was done under the supervision of D. Ransom Whitney, Ph.D., Director of the Statistical Laboratory, Department of Mathematics, The Ohio State University, and his assistant, Mrs. Lydia Kinzer, M.A.

and finally in the eighth, and the other half in the second and ninth. All were examined from one to three times in between. The final examination was a complete visual analysis made in November, 1953, at the clinic, School of Optometry, The Ohio State University. The standard used was the full correction of astigmatism, and maximum visual acuity with full inhibition to accommodation. In addition the following tests were used. 1. California Achievement (prior to 1950 titled Progressive Achievement) Reading and Arithmetic subtests. The California Test Bureau, Los Angeles. 2. California Test of Mental Maturity. The California Test Bureau. 3. The Stanford-Binet, Form L.

The first test and all intervening tests, were screening tests performed at the school by senior students of the School of Optometry, The Ohio State University, under faculty direction and supervision. Various procedures were used at different times, such as estimating the refractive status of the eyes by measuring visual acuity through plus lenses of varying powers, or measuring it by retinoscopy. The stereoscopic and fusional tests originally instituted by the author were not made during his absence in the service and were reinstated in the final examination which was performed in some detail as a complete refraction at the University Clinic.

Standards established for: 1. Visual Acuity at 20 feet. Snellen letters or for younger children the placing of the illiterate "E." Normal: 20/30 Age 7 and under. 20/20 Age 8 and over. 2. Refraction. Normal: Less than +2.00 D. age 9 and under: +1.00 D. or less over age 9; no myopia in any degree. 3. Visual Acuity at near point. Normal: Same as at 20 feet. 4. Muscular Balance at 20 feet. Normal: 5Δ of esophoria to 5Δ of exophoria, inclusive. This can be picked up by alternate covering of the eyes by a card, while fixating a distant spot or point of light, or in the Keystone Telebinocular by accepting the arrow pointing to the numbers 8, 9, or 10 (the 9 only is listed as expected) in test #3. Vertical balance: Zero, or not over 1Δ. This requires a rotary prism, a doubling prism and card, or a Keystone Telebinocular using test #2. 5. Muscular Balance at Near Point. Normal: 4Δ of esophoria to 8Δ of exophoria inclusive. This may be determined by use of a hand rotary prism, a single vertical doubling prism and a suitable measuring card, or a Keystone Telebinocular by accepting the range 4, 5, and 6 instead of the #5 only as listed by Keystone. 6. Fusion: Normal: Fusion with amplitude, as indicated by superimposing the line and ball in the Keystone card, normal recoveries in the vergence tests, 3 balls or 4 to 3 on Keystone tests #4 and #11, or

preferably a fair degree of stereopsis as measured on the Keystone Visual Skills Test #7, or similar instrument. 7. General observation. Normal: Normal fixation of the eyes on a distant object; at a near point target moved vertically, horizontally, and in rotary motion; and convergence to at least 3 inches from the bridge of the nose. Normal appearance of the eyes, pupils, lids, no unusual redness or swelling.

DISCUSSION

After following these children for a period of seven years, and comparing their visual ratings with their school performance, several points stand out very clearly. These are: 1. A screening test is just that, and is *not* an eye examination or visual analysis. It is usually done in a hurry by individuals not trained as optometrists or ophthalmologists, and with a minimum of equipment. It is therefore merely an indication, and passing the test is no guarantee of the absence of a visual problem, though failure does indicate the advisability, though not the absolute necessity, of further and more complete investigation.

For example, there may be retinal pathology or abnormalities which can only be detected by a trained person using the ophthalmoscope. There may be a degree of astigmatism, sufficient to cause considerable strain resulting in an aversion to reading, but not enough to cause reduced acuity in these young individuals with a high amplitude of accommodation.

There also may be phoria problems great enough to indicate the need for lenses or visual training procedures in a screening test which are found to be adequately compensated for by the opposing ductions when making a complete examination. A child might be passed with 20/20 vision, and phorias just inside normal limits; yet he may be starting to develop myopia, which would be picked up in a complete examination, allowing early corrective procedures to be taken and avoiding a much more serious problem later on.

Fusional ability is most important, especially in children. It is not the one eyed person or the squinter (crossed eyed individual) who has already blocked out the vision of one eye who is the reading problem. It is the two eyed person with normal vision in each eye, who is straining to overcome a muscular imbalance to avoid seeing double. So a failure on both phoria and fusion tests, especially at near point, is most significant and warrants a complete examination.

Stereopsis is generally conceded to be the third and most highly integrated stage in the development of fusion. It is probably of no help as such in reading letters on a flat page. Deficient stereopsis, how-

ever, is considered most significant in that it indicates a failure in the complete development of the fusion faculty, and is frequently associated with a lack of interest in reading.

2. All people concerned must agree on the purpose of a screening test. Correlation between screening results and scholastic achievement is not as high as some educators would like. That does not bother the eye specialist at all because he sees another purpose which is just as important. It is the invidual as an individual, not just as a student.

3. It is important to identify in the first and second grade the child who is visually immature, i.e. who has high hyperopia, esophoria, subnormal acuity and underdeveloped fusion, and to warn the teachers not to frustrate him by forcing him into close work until he is ready for it.

4. It is equally important to pick out the child who is going into myopia or excessive esophoria in order to take corrective action for his own future good even though his school work may be excellent. This may even mean reducing the amount of near work required by the teacher and parents: insistence on proper visual habits and working distance, and the encouraging of more outdoor and athletic activity at the expense of reading time. In the present study, of fifteen children with visual problems, six or 40% are doing excelent work scholastically, but four of them have become near-sighted and one cross-eyed in the process. It would seem that we should be as much interested in preventing our good students from becoming visually handicapped, as we are in identifying our visually handicapped so that they may be corrected and become good students.

REPORTING OF VISUAL EXAMINATIONS

Subjects were rated and reported to parents and school authorities in three categories: A. Normal: When all screening tests were within normal limits. B. Possible strain or visual fatigue at near point: This was used, and the notation added for first graders, "Do not force reading," where the tests indicated a fairly high hyperopia, but no other symptoms: phorias toward the high limit of esophoria: or on the Keystone when either the phorias or fusion tests were failed, but not both. C. Visual Problem: Refer: These children were significantly outside normal limits and were felt to need a complete refraction.

DISCUSSION OF THE FINDINGS

For the purposes of this study the children were classified into four groups on the basis of visual findings: Group I, N = 11: Normal throughout. Group II, N = 7: Initial visual problems improving during period. Group III, N = 3: Initially normal developing into

visual problems, or suspected visual problems. Group IV, N = 16: Visual problems throughout. Total N = 37.

Table I indicates that with one exception, all of the 38 children in the study have intellectual ability within or above average limits. It is interesting to note that the "one exception," classified as Dull Normal has been consistently above the grade norm in reading, third through seventh grades. Her record in arithmetic does not equal this, but is not seriously low. She entered seventh grade with a grade norm of 5.9 in Arithmetic Fundamentals, and 6.8 in Arithmetic Reasoning. Her teachers report that she is a steady, consistent worker.

TABLE I

INTELLIGENCE QUOTIENTS AS MEASURED BY THE STANFORD-BINET, FORM L AT THIRD GRADE LEVEL

Intelligence Quotients	Group I Boys	Group I Girls	Group II Boys	Group II Girls	Group III Boys	Group III Girls	Group IV Boys	Group IV Girls
Superior: 120 and above	1	6	2	—	1		1	4
Average: 90-119	2	2	3	3[1]	—	1	4	4
Dull Normal: 80-89	—	—	—	—	—	1	—	—
Total	3	8	5	3	1	2	8[2]	8

[1]One of these three girls was unavailable for final visual examination.
[2]No record available at Third Grade for three of these boys. At First Grade two were in the Average classification, and one in the Superior.

Table II presents a detailed picture of our findings in terms of visual diagnosis, academic achievement on entering seventh grade, and pertinent comments as to educational history of the children.

This table summarizes the data on 37 of the 38 children, since one girl was not available for the visual examination in November, 1953. A few generalizations can be drawn from this table:

a. Of the 37 children, only 11 were found to have normal vision throughout the period of our study, group I;

b. Only one (a girl) of these eleven children was found to be seriously retarded academically, and that in arithmetic;

c. In Group II (Initial visual problems improving throughout period) the academic pattern tends to be one of a slow start, erratic achievement, or both.

d. All three children in Group II (Initially normal developing into visual problems) have satisfactory achievement on entering seventh grade. However, one boy was slow in developing reading skills, and was tutored.

e. Of the 16 children in Group IV (Visual problems through-

TABLE II

COMPARISON BETWEEN VISUAL STATUS AND ACADEMIC ACHIEVEMENT UPON ENTERING SEVENTH GRADE

Group	Visual Diagnosis	Achievement Upon Entering Seventh Grade	Comments
I: 3 boys 8 girls	Normal.	Reading and Arithmetic O.K.: 2 boys, 4 girls. Reading O.K. and arithmetic unsatisfactory: 3 girls.	One of these boys is so emotionally disturbed that he rarely relates to groups. One girl (IQ 121) was below norm only one month; one girl (IQ 128) dropped slightly below norm for the first time; the third girl (IQ 112) has had several severe traumatic episodes.
		Arithmetic O.K. Reading unsatisfactory: 1 girl.	IQ 109, only one month below norm in Reading vocabulary at seventh, and well above on entering eighth.
		Reading and Arithmetic unsatisfactory: 1 boy.	IQ 108, history of delayed language development; has been making slow, but consistent progress; above norm in reading at eight, and only one month below norm in Arithmetic Fundamentals at seventh.
II: 5 boys 2 girls	Initial visual problem, improving during period.	Reading and Arithmetic O.K.: 2 boys, 1 girl.	The girl was born prematurely. Her immaturity has been demonstrated in physical and social growth rather than in academic achievement.
		Reading O.K., Arithmetic unsatisfactory: 1 boy.	Reading, a very slow start; Arithmetic reasoning is improving; fundamentals still poor.
	A myope who had no lenses until 9th grade.	Arithmetic O.K., Reading unsatisfactory, 1 girl.	Erratic pattern of achievement throughout.
	Both visual problems through 3rd grade. One in 5th grade before getting lenses, the other doesn't have lenses yet.	Arithmetic and Reading unsatisfactory: 2 boys.	One who has never had lenses has manifested emotional problems throughout. The problems of the other one have been mostly academic

Group	Visual Diagnosis	Achievement Upon Entering Seventh Grade	Comments
III: 1 boy 2 girls	Initially normal developing into visual problems or suspected visual problems: one (girl) was becoming myopic, two were becoming excessively esophoric.	Reading and Arithmetic O.K.: all three children.	The one boy (IQ 126) had a very slow start in reading and was tutored: Arithmetic consistently satisfactory. Total achievement superior in 9th grade. One girl (IQ 85) at norm throughout in reading. Arithmetic Fundamentals has tended to be low. (See comments on Table I.) One girl (IQ 108) delayed entering First Grade one year because of general immaturity. Academic progress has been consistently satisfactory. All visual problems developed fairly late in the period, and apparently are not affecting school work. Did the stress of close work contribute to the development of these visual problems?
IV: 8 boys 8 girls	Visual problems throughout 4 developed into myopes: one into a squinter (crossed eyes) with complete suppression of one eye: and one into an esophore with astigmatism.	Reading and Arithmetic O.K.: 7 girls.	All of these girls tend to be withdrawn in their social relationships.
	Esophoria with astigmatism.	Reading O.K. Arithmetic (fundamentals) unsatisfactory: 1 girl.	Very shy and withdrawn.
	Both astigmats.	Arithmetic O.K., Reading unsatisfactory: 2 boys.	One boy asthmatic, and has a poor attendance record due to illness: reading improving. The other boy has had tutoring in reading, but progress has been slow: good in athletics. Both boys accepted socially.
	Three of the six boys are wearing lenses. One did not get lenses until fifth grade.	Arithmetic and Reading both unsatisfactory: 6 boys.	One boy wore a patch for two years: all boys have been socially maladjusted, and school achievement has been consistently below expectancy. One of these boys is showing skill in basketball.

out), 7 of the 8 girls are at norm or above in their academic work. However, they tend to withdraw from the social activities of the school.

f. Nine of the group are educationally retarded in reading, arithmetic, or both.

g. If it is considered that four of the seven in this visual problem group who are doing normal academic work are myopic (near sighted), which does not normally interfere with reading and other close work; and one has solved her problem by relinquishing binocular vision through crossing, and suppressing the vision of one eye: we obtain a rather surprising correlation between visual problems which may be expected to interfere with academic work and actual academic scores.

Of a total of 11 visually normal, 9 or 81.8% were satisfactory in reading and 6 or 54.5% satisfactory in both reading and arithmetic. On the other hand, of the 11 of the 16 visual problem cases, which might be expected to interfere with school work 8, or 72.7% were unsatisfactory in reading and only 2, or 18% were satisfactory in both reading and arithmetic.

The visual findings: Of the 37 children for whom complete refractive data were available, 14 or 38% started out as hyperopes of +1.50 D. or greater. At the end of the period the mean was +0.31 D. or a decrease of over 1.25 D. The final range was from —1.25 D. (1) to +1.00 (2). There were five in the low refractive range of from less than 1.00 D. of hyperopia to less than 1.00 D. of myopia. Their final range was from —0.75 D. (1) to —3.00 D. (1) with a mean of —1.85, or over a 1.00 D. increase in myopia. There were 15 low hyperopes and no initial high myopes. Considering the entire group—hyperopes, myopes, and negatives or low errors, there was a mean change toward decreased hyperopia or increased myopia of 1.2 diopters. The range was from no change (3) to —3.00 D. (3). In no case was there any indication of an increase in hyperopia. For 22 of the 37, or approximately 2/3 there was a change of —1.00 D. or greater.

A statistical analysis of these figures indicates that this trend is significant to well below the 1% level, and therefore could hardly have occurred by chance.

An analysis was next made of the muscular balance findings. Of nine children with exophoria outside normal limits at the start, seven were hyperopes, four of them +1.00 D. or greater. Of nine, six ended within normal limits, and three developed into esophoria. Of 10 children with initial esophoria, six were low refractive errors and three were high hyperopes, one was a high astigmat and was excluded. Of the nine, six ended within normal limits and three were still esophores.

One developed strabismus complicated by a vertical imbalance and the complete suppression of one eye.

Nineteen individuals started with phorias within normal limits. Thirteen ended the same way, six developed into esophories. Of 37 for whom the records are complete and who retained binocular vision, 1/4 started out as exophores, 1/2 as normals and 1/4 as esophores. In each group 2/3 ended within normal limits and 1/3 as esophores, regardless of where they started.

All children who failed to make the expected four year progress in reading comprehension and reading vocabulary progressive achievement scores from fall of second grade to fall of sixth grade had at one time a fusion or astigmatic problem, or both. There seems to be little relation between these visual problems and arithmetic score improvement.

SUMMARY

1. This longitudinal study is concerned with the visual, academic, and intellectual growth and development of 37 children, 17 boys and 20 girls, as they progress from grade to grade through the elementary school.

2. These children are attending a suburban school in a high average socio-economic community.

3. Results on the Stanford-Binet, Form L, indicate that 15 rate as superior with IQ's of 120 and above, 19 within average limits with IQ's ranging from 90 to 119, and one falling within the dull normal classification. (For three boys no test results were available at third grade.)

5. Only 11 of the 38 children were found to have normal vision throughout the period of our study.

6. A first or second grade child who starts out with a reserve of at least 1.00 D. to 1.50 D. of hyperopia has a fair expectation of ending his elementary school career with a normal or low hyperopic condition.

7. The child with no refractive error at the start will probably end up myopic.

8. The data show a positive relationship between visual maturation and visual problems.

a. Those children who were rated as visual problems during their early school years in many cases seem to have had a poor start academically from which it has been difficult to recover.

b. The children who were normal throughout the period until toward the end remained good students.

c. It seems that the visual problems, developing myopia and esophoria are often associated with excessive close work, and

are more likely to be induced by school work than to affect them.

d. An increase in esophoria at near is a danger signal, not just for visual care, but also to check for poor reading habits, posture, working distance or disturbing factors at home or school.

9. The data show a positive relationship between visual maturation, visual problems, and academic achievement:

a. In Group I (normal vision throughout) only one of 11 children is manifesting an academic retardation. The cause, apparently, is an emotional one.

b. In Group II (Initial visual problems, but improving), four of the seven (one girl, three boys) are still academically retarded. These four tended to be slow in starting and have shown erratic patterns of development. Three at the 7th grade level were still below the norm in reading; and three below in arithmetic.

c. In Group III (Initially normal, developing into problems): no academic retardation on entering 7th grade.

d. In Group IV (Visual problems throughout), nine of the 16 children are showing some academic retardation, one girl in arithmetic, all of the boys in reading, and six of the boys in both arithmetic and reading.

QUESTIONS

If we accept as the normal pattern of visual maturation, a progression from hyperopia to emmetropia and possibly myopia, then a few questions are suggested on the basis of our findings. There was found to be a trend in refraction toward myopia, or focus at near point instead of distance, and a trend in muscular balance away from the parallel toward over-convergence even within the distance at which reading material is held: Are we starting our close work too soon? Are we placing too much stress on close work at home and school in the early elementary grades? Is there an inadequate program of teaching visual hygiene so that a normal balance of near and far activity results? Are we evaluating children's vision early and thoroughly enough?

CLINICAL OBSERVATIONS ON THE FITTING OF MICRO-LENSES*

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The first practical use of contact lenses seems to have occurred in 1887 and since this time drastic changes have taken place in their application, theory, design and the techniques employed in fitting them. Many significant events can be selected as important contributions in the development of this field of visual science. Two parallel methods of fitting contact lenses can be traced, and both of these have been found to possess certain advantages to the patient and to the optometrist. Dallos, Salvatori,[1] Obrig,[2] Anderson,[3] Freeman[4] and others have made significant contributions in the development of moulding techniques. The discovery that an anaesthetic was not required in this method placed it more readily within the field of optometrical service. The moulding method was paralleled by the emergence of several trial case methods of fitting through the efforts of Feinbloom,[5] Greenspoon,[6] and Butterworth,[7] among others. The change from glass to plastic contact lenses was an important development and contributed to wider use. The introduction and development of the corneal contact lens in 1948 by Tuohy[8, 9, 10] stimulated a greater interest in fluidless types of contact lenses. Bier[11] developed the fenestrated lens, Dallos introduced a minimum clearance lens, Obrig introduced the "Lacrilens," and many others have appeared in recent years. Probably one of the greatest contributions has been the development of the micro-lens by Sohnges, Dickinson, and Neill. Due to the nature of this lens, the method of fitting is an art rather than a science, so that it is difficult to describe precise fitting techniques in any articles. The earliest reports on these lenses have been published by Dickinson and Neill in English and American Journals.[12, 13]

Due to the lack of definite information about the micro-lenses, a small research group was organized at the end of July, 1954, at the College of Optometry of Ontario to determine more precisely the method of fitting these lenses, and to attempt to improve upon them. This group included three optometrists, W. Atkins, D. Solomon and

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the author, and two technicians who produced the lenses, E. Millington and H. File. This article is a report of their observations and findings.

The research group proposed to undertake the fitting of as many patients as possible with the new small size corneal lens, or microlens. It was intended to observe and record detail obtained in the study, and to develop fitting procedures which could be universal. Patients were obtained from a number of sources, and a total of 53 patients have been fitted. Thirty of these patients had been fitted with various types of contact lenses previously, and could not wear their lenses with any degree of satisfaction. This group of patients was obtained from six or seven different practices and was unselected as far as suitability for wearing contact lenses was concerned. The other 23 were new patients from the practices of the members of the research group and a few referred patients. The new patients were selected by the members of the research group in that it was felt they were good risks for the wearing of contact lenses generally. In the selection of patients consideration was given to the type and amount of ametropia, the purpose for which lenses were intended, the apparent personality characteristics of the patient, and similar factors. The patients fitted were principally myopes, ranging to 23 D., and including two patients with keratoconus, and one patient requiring a cylindrical correction of 6 D.

The first problem confronting the group was the construction of a satisfactory trial case. The research group was dissatisfied with existing trial cases, in that the intervals between the curvature of the lenses was one diopter. Further it was felt essential that extreme accuracy was necessary in the curvatures of the surfaces. Close inspection of one of the existing trial cases revealed a discrepancy between O and 1.50 D. from the marked power of the lenses. Hence a trial case was designed with 0.25 D. intervals between the different curvatures and ranging from 38.25 D. to 46.00 D. These lenses were all accurate to 0.12 D. They were all plano in power, and between 0.1 and 0.2 millimeters in thickness. There were 32 different curvatures and the lenses were originally made in pairs 9.5 mm. in diameter. Later 10.0 mm. lenses were added and some 10.5 mm. lenses.

A Bausch and Lomb keratometer was used for the measurement of corneal curvatures. The eyepiece of this instrument was focussed for one observer by means of a $\frac{5}{8}$" steel ball which required a reading of 42.50 D. Feinbloom has suggested that it would be advisable to determine the average error of the observer, and it is proposed to do this on a group of patients as this research project continues. It is a

well-known fact that the corneal curvature varies from the central to the peripheral areas, being more convex in the central area and flattening out towards the corneo-scleral junction. In this connection, an interesting opportunity for research presents itself, since it would appear that there might be some relation between the amount of difference between the corneal curvature and the contact lens curvature, and the amount of difference in corneal curvature from the center to the periphery of the cornea. This aspect of the work has not been pursued to date, but it is anticipated that research along these lines will continue in the future by this group. Articles by Neill indicate the "spread" or difference of curvature between the lower corneal reading and the contact lens reading amount to 3.00 D. to 5.00 D. Because of previous experience with other types of corneal contact lenses, this group considered that such spreads were rather high, and at first decided to use 2.00 D. to 3.00 D. differences between the lower corneal curvature and the curvature of the contact lens. This figure was changed later in the study to 1.00 D. to 2.00 D. and has since been reduced to less than 1.00 D. in most cases. Neill has since pointed out that the lenses with which he has worked have no bevel on the inner surface, whereas those used in this study have a standard bevel or "lead" of 0.5 to 1.0 mm. width.

The procedure followed by this research group was to measure the corneal power with the adjusted keratometer, and use the lower corneal reading. A trial lens was selected from the trial case by deducting 2.00 D. from the lower corneal power and fitting that lens to the patient's eye. The usual Barnes-Hind wetting agent was used on the lenses, and they were rinsed with clear water. The patient wore the lenses for a period of two to four hours and the fit of the lenses was observed using fluorescein and ultra-violet light. The fit of the lenses was observed three or four times in the course of this period, and was also observed using normal illumination. According to the information obtained from these observations, a suitable lens would be prepared by the laboratory incorporating any spherical refractive correction required. On a succeeding visit, the patient was instructed in the method of handling this type of lens, and was allowed to wear the lenses for two weeks. He was instructed to wear them not more than three hours a day for the first week and not more than four hours a day for the second week. At the end of this time, he was again examined as before and where necessary, any changes in lens power, curvature, or size were made.

In order to clarify our thinking on the type of result we hoped to achieve, an attempt was made to set down our conception of a well-

fitted micro-lens. The lens must be well centered in the horizontal meridian when the eyelids are in their normal position, and the patient's head and eyes are in the primary position. If both lids are raised slightly away from the globe, the lens should slide downward very slowly until the lower edge of the lens rested against the sclera or limbus area. Using fluorescein and ultra-violet illumination, the central half of the lens should show as a dark area, and the peripheral portion of the lens should not touch the cornea in any way. No corneal abrasion should be visible under ultra-violet illumination after the lens has been worn for at least four hours. The presence of these abrasions was considered to indicate a faulty fitting lens. The patient should experience no symptoms of extreme discomfort during the trial wearing period.

Some of the unsatisfactory conditions encountered, and the methods of correcting them can now be considered. It was found that a lens which did not center well on the cornea, sliding to the nasal or temporal side, could be improved both in comfort and appearance by using a slightly larger lens. The size of the best-fitting lens seemed to be about one millimeter less than the diameter of the cornea. A lens which dropped too rapidly when the lids were held away from the globe could be improved by selecting either a tighter lens, or a slightly larger lens. The size of the lens was considered first, and if it appeared to be as large as the cornea would allow, than the curvature was tightened 0.50 D. If the central dark area appeared to be smaller than the middle half of the lens under ultra-violet illumination, then a tighter lens was selected from the trial case. If this same area appeared to occupy more than the central half of the lens, a looser lens was selected from the trial case. Similarly, a looser lens was selected from the trial case if there was any evidence of the peripheral edges of the lens touching the cornea. In a few cases, it was found necessary to select a lens where this touch at the periphery occurred, and then have the laboratory put wider "leads" on the edges of the lens.

Many corneal abrasions were observed and they tended to group themselves into certain categories. If the corneal abrasion occurred at or near the apex of the cornea, a slightly tighter lens would be prescribed. If the abrasion was slight, the amount of tightening might only be 0.25 D., whereas if the abrasion were extensive, then a tightening of as much as 1.00 D. might be used. An abrasion which appeared in the peripheral region of the cornea was usually corrected by making the lens 0.5 mm. or 1.0 mm. larger. It was found that patients could not tolerate their lenses when abrasions were present. The abrasion tended to make the eye water extensively. It was not the experience of this

group, that abrasions disappeared after the tolerance of the patient increased. Another difficulty encountered was the presence of light flashes around the edges of the lens. This seemed to be due to the irregular distribution of tear fluid, and was relieved by using slightly larger lenses.

The optimum relationship between the curvature of the lens and the lower curvature of the cornea varied from 0.25 D. to 3.00 D. The frequency distribution curve of this group of patients shows a bi-modal type of frequency with the largest proportion having a spread of 1.00 to 1.75 D. Over half of the eyes were fitted with 1.25 D. spread. A much smaller number of patients seemed to fall between 2.25 and 2.75 D. spread. Figure 1.

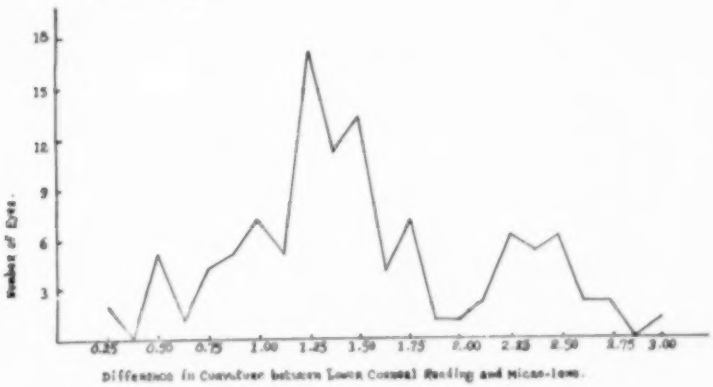

Fig. 1. Distribution curve of amount of spread.

The final results of this study cannot be given at this time, since work with all of the patients has not been completed to the satisfaction of the research group as yet. It should be remembered that many of these patients were dissatisfied with their previous lenses, and therefore can be presumed to present difficult problems in contact lens fitting. There have only been two or three instances in which the wearing time by this method of fitting has not exceeded the patient's previous experience. In several instances, patients have been able to wear their lenses 14 to 16 hours without discomfort or abrasion. The research project is not yet finished, and it is intended to determine the average wearing time of all these patients. A first approximation would indicate that this might be between 6 and 7 hours.

A further observation has been made by the members of this group concerning the apparent prominence of the cornea. It seems

that there are various degrees of prominence of the cornea, apart altogether from the curvature of its surfaces. In some patients it appears to protrude from the sclera a considerable distance, while in others it is practically continuous with the sclera. No satisfactory method has been found to measure this, but the project is continuing and an attempt will be made to assess this factor. It may be that the amount of spread is related to this prominence of the cornea. If this is so, it will enable the fitter to obtain a better effect with less difficulty. It has also been observed that the cornea is not smooth over its entire surface. Corneas have been observed which appear to have ridges or valleys on the surface. Some of these are concentric with the center of the cornea, others appear to be radial.

Two other factors appear to be rather important in the successful use of the micro-lens. The patient must use a good amount of wetting agent on the lenses to be comfortable. Sometimes it was found helpful to place a drop or two of wetting agent above the lens when it was in position over the cornea. After blinking once or twice it was evenly distributed and this improved the patient's vision and comfort. This was done not only after first insertion but also after several hours of wearing with good results. The final observation is that the "break-in" period for these lenses must be gradual. Not more than three hours wearing at a time for the first week, with gradual increments in time to the optimum period seems to be most satisfactory.

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REPORT OF VISION SCREENING TESTS IN A GROUP OF TEN READING PROBLEM CASES*

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In 1950 we conducted at a remedial reading center near Boston a vision screening program of a group of ten students. The primary purpose of this was to prove or disprove my belief that in reading disability cases: (1) Stereoscopic instrument tests alone are not sufficient for determining the status and functional performance of the oculomotor apparatus. (2) Observation of the ocular muscle action in the up, down, up and out; up and in; down and out and down and in directions, is an essential part of a visual examination. (3) The presence of fusion at the far point does not indicate that this function is also normal at the near point. Observation, together with stereoscopic instrument tests, I believed, would give the examiner a broader understanding of the case. In some instances the findings might be incompatible, as for example, instrumentally vertical orthophoria even though one eye appears by inspection to be higher than its mate. From a clinical aspect such testing gives a more complete picture of the condition of the motor apparatus.

All of the students in this investigation, had previously been examined under cycloplegia. Some had ophthalmic correction and others did not. Also, the muscle balance and fusion faculties had been investigated. The Maddox rod and/or the displacing prism tests were used to determine phoria, while the Risley prism was used for measuring the ductions. Fusion was tested with Wells cards, and, according to the reports, all tests were made only at the far point. Because cycloplegia had been used, no tests had been made to determine amplitude or reserves of the accommodation.

The instruments used in conducting the screening tests in this report consisted of: 1. a Keystone telebinocular. 2. Keystone targets DB 10A; DB 4K; DB 5K; BU 5; BU 6; DB 6D; DB 8C; DB 9; DB 9A and Retinal Rivalry card (RR 1). 3. a Prince Rule. 4. a Maddox rod. 5. cross cylinders. 6. a phorometer with Risley prisms.

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7. A.O. Co. test cards (a) for visual acuity at far and near points; (b) for testing and measuring muscle balance, ductions and fusional reserves at near; (c) cross cylinder card with reduced Snellen letters on reverse side.

Tests were conducted in a well-lighted room with the vision chart placed at 20 feet, level with the subject's eyes. A small spot of light behind the chart served as the fixation target for testing the muscle balance.

The following were observed or tested: 1. Visual acuity at distance and near. 2. The fundi and media by ophthalmoscope. 3. Tonicity or muscle balance (phoria) in horizontal and vertical meridians, at distance and near. 4. Ductions, versions, vergences, and motility in general at far and near points. 5. Fusional reserves break and recovery. 6. Accommodation amplitude and reserves. 7. Quality of sensory perception, especially that of foveal fusion at far point and near. 8. Observation of postural and proprioceptive functions. 9. Handedness, eye dominance and other characteristics.

Nine of the ten subjects were boys, ranging in age from 9 to 31. The one girl was 15 years old.

AIMS AND OBJECTIVES

The visual and ocular muscle tests reported in this study, were undertaken for the purpose of establishing the adequacy or inadequacy of instrument tests alone, particularly when the problem is one of reading disability. Particular care was exercised in determining and evaluating the various visual and spatial skills. Performance was tested of the individual component functions and all data were recorded as observed. However, specific study was made of those functional abnormalities which might be either directly responsible or indirectly contribute to reading disability. A primary aim, of course, was to determine whether corrective measures should be instituted. As is already known, some form of remedial intervention is especially indicated, if, after repeated testing and careful study, discrepancies continue to exist between instrument findings and those by observation. In many such cases, a type of vicarious compatibility may develop between what might be regarded as normal perceptual functions with those which tests indicate as being defective. Such manifestations are not uncommonly observed in eye muscle examinations. They may occur as secondary deviations, variable suppressions, face turning and head tilting — all of these tending to serve as compensatory actions. On the basis of clinical experience we feel that these vicarious adjustments are acquired during the formative years, and before the fusion faculty is fully developed.

No refractive examinations were made during any of these screening tests. All testing was confined entirely to the neuro-muscular and sensory apparatus. Inasmuch as all tests were made both at the far point and at near, no cycloplegia could be used. Many of the tests made are special tests which are not performed routinely in all eye examinations. They require special apparatus and specialized techniques. Inspection and observation of muscle function and performance played an important role in this study. These helped to clarify and explain many of the discrepancies in the tests which showed up, and which are recorded.

CASE REPORTS

Case #1. Miss G. K. Age 15. Visual acuity with and without glasses: right eye 20/20, left eye 20/20 (central or macular vision). The patient had glasses for near use only. These relieved the symptoms of eyestrain.

Muscle balance tests with Keystone DB 9 and 9A cards indicated, 6Δ to 8Δ esophoria at distance and 2Δ to 3Δ esophoria at near. Central (foveal) fusion at distance and near was absent when tested with Keystone DB 4 and 5 cards. These latter two anomalies could be attributed at least partly to a defect of the muscles concerned with supra-version of the left eye. When both eyes were made to elevate simultaneously, the right one appeared to be higher than the left. Yet, there were no symptoms of physical discomfort reported, nor did an anomaly of the vertical muscles show up when tested with stereoscopic apparatus and Keystone DB 8C card. The same anomalies were evident with and without optical correction.

Accommodation varied in extent for each eye during this test. O.D. was 10 D.; O.S., 13 D. Binocular perception was present, but it was not bifoveal. There was indication of intermittent macular suppression.

Absence of foveal fusion, maladjustment of the two eyes in the horizontal and vertical meridians, variation in amplitude of accommodation, and intermittent suppression, even if periodic in appearance, are considered to be contributing factors in anomalies of reading. Furthermore, they may amplify other defects of visual perception and strongly affect any of the dependent functions.

Case #2. P. D. M. Age 9. Male. Visual acuity: right eye 20/20—1, left eye 20/20 (central or macular vision). This patient had no glasses and could read smallest size Jaeger type at normal reading distance.

The patient had face turned toward the right with tilting of the

head. When looking intently at some specific object, he showed tendency to turn the head as if looking from the corner of the eye, instead of fixating the object directly. When both eyes were open normally, the palpebral fissure of the right eye appeared to be narrower than the left. In such patients we look for possible deficiency of the muscles concerned with elevation, and with their movements in the vertical and oblique areas of gaze. In this case tests revealed a discrepancy in binocular alignment during elevation. The right eye did not rise to the same level as the left. Convergence near point was at tip of nose. Amplitude of accommodation was 6.5 D., each eye. Projection by the Maddox line test was faulty, showing abnormal spatial sense. This is a common complication in deficiencies involving the vertical muscles. This boy learned to overcome the acquired defects by tilting his head and by turning his face away from the position of fixation which he found annoying. Such vicarious adjustment of head and face helped him to get along well visually. This, however, does not help to permanently eliminate the postural deficiencies of the visual apparatus and all the dependent functions. However, it helps to mask them sufficiently to serve an immediate need while, at the same time causing the acquired maladjustments to become intensified and habitual.

With Keystone DB 9 card, muscle balance test showed between 8Δ and 9Δ esophoria at far, and between 3Δ and 4Δ esophoria at near point. Vertical orthophoria was indicated with the Keystone DB 8 card. Reading was a slow, laborious task, yet this boy was able to read a book held upside down with the same degree of facility as if it were held in the proper position.

Foveal fusion at far and near points seemed normal when tested with the Keystone DB 4 and 5 cards, but with Keystone BU 5 and 6 cards, he past-pointed quite considerably. This confirmed the Maddox line test for projection, made earlier.

All oculomotor and perceptual defects found in this case could very well be considered as culpable, or at least, contributing factors for the reading defect.

Case #3. P. F. M., Age 13, Male. Visual acuity: right eye 20/20, left eye 20/20, (central or macular vision). The patient had no glasses. Near vision was normal. Convergence near point to tip of nose. Cover test showed no deviation.

This patient had pronounced face turn toward the left, but no head turn. Anatomically, the left orbit appeared to be higher than the right. The face turn, therefore, may be of a compensatory nature. Tests indicated the various basic visual skills and spatial and perceptual

functions to be normal, or within normal limits. However, in those binocular functions which depend on postural alignment of head and face, performance was somewhat below normal. This may have been due to facial assymetry or to unfamiliarity with tests. Repetition of tests indicated the latter. Hence, the probability was that in this case the visual apparatus was not responsible for any existing reading disabilities.

Case #4. J. E. M., Jr., Age 13. Male. Visual acuity: right eye 20/20, left eye 20/20, (central or macular vision). The patient could read smallest size Jaeger type at normal reading distance. The patient had no glasses.

External examination of the eyes by inspection of muscle functions in the six cardinal directions, and tests of performance of the various component functions of the binocular apparatus at the far point, showed no apparent abnormalities. However, at the near point (which corresponds to the area of his defect) repeated tests showed absence of foveal fusion.

Muscle balance tests made with Keystone DB 9 card showed: 9Δ esophoria at distance and 4Δ exophoria at near. Convergence tests showed that function to be normal. The amplitude of accommodation was 10Δ for each eye. The cover test showed no heterophoria at any distance. It is doubtful, if in this case, the visual apparatus was responsible for the reading disability, defective fusion at near notwithstanding.

Case #5. Mr. D. B. A., Age 17. Visual acuity, without glasses: right eye 20/200, left eye 20/200, (central vision). With glasses: right eye 20/40—2, left eye 20/40—1, (central vision). O.U. 20/30—. The patient had been told this was the best acuity possible. He was using O.D. —2.75 D. sph. $\bigcirc$ —2.00 D. cyl. axis 30, O.S. —3.00 D. sph.

Aside from defective sight with present glasses, this patient showed no abnormality of any of the visual skills or of the uniocular and binocular perceptual functions. Convergence near point was to tip of nose. The amplitude of accommodation was 13 D. for each eye. Muscle balance tests: orthophoria to ½Δ exophoria at distance and 3 to 4Δ exophoria at near. Vertical isophoria. Muscle performance by inspection disclosed no abnormalities of either the lateral or the vertically acting muscles. Fusion was normal at all distances. All sensory and proprioceptive functions appeared to be normal. The reading disability was not due to visual defects.

Case #6. Mr. L. N., Age 18. Visual acuity: right eye 20/20, left eye 20/20, (central or macular vision). This patient had no

glasses. Near vision, read smallest size Jaeger type at normal reading distance.

The patient had a head tilt toward the left shoulder. As mentioned earlier, in such cases we look for possible deficiency of the muscles concerned with elevation and with ocular movements in the vertical and oblique areas. Here both the instrument test with the Keystone DB 8C card and inspection revealed right hyperphoria with an alternating exotropia apparent by the cover test. Convergence was obtained with difficulty. Alternating exotropia was apparent when convergence was forced. Tests with Keystone targets DB 10A showed presence of simultaneous binocular perception. For DB 9 card, at distance the arrow pointed between 7 to 8; at near the arrow pointed between 4 and 5. Fusion was tested with Keystone DB 4 and 5 cards. At the far point, it was absent at the start, but became manifest after prolonged fixation and remained so. At near, fusion was manifested from the very start. Yet tests for bifoveal fixation showed alternating central fixation with intermittent central suppression. Test for determining quality of retinal rivalry showed that function to be normal.

The presence of compound muscle deviation invariably prevents use of the two eyes as a single unit. Additional tests showed that fixation was alternating and not simultaneous as shown earlier. The eye not called into use was momentarily suppressed or inhibited. Such anomalies seriously interfere with concentrated visual performance especially at near. It was difficult to explain the presence of normal retinal rivalry and fusion, especially at near despite alternating exotropia, right hyperphoria and intermittent central suppression. Any one of these anomalies may be a causal factor in reading problem cases.

Case #7, Mr. D. D. W., Age 19. Visual acuity: right eye 20/20, left eye 20/20, (central or macular vision). This patient had no glasses. Near vision, smallest size Jaeger type at normal reading distance.

The patient had face turn toward the right with head turn to the left. When both eyes were open normally, the palpebral fissure of the right eye appeared by comparison, slightly narrower than the left. With such patients, we look for a possible deficiency of the muscles concerned with elevation, and with their movements in the vertical and oblique visual fields. In this case, objective tests, by inspection, revealed that when both eyes were made to elevate simultaneously, the right appeared at a higher level than the left. Moreover, the right eye showed a tendency to turn downward and outward when both eyes were depressed and directed in a straight downward position. However, the extent of turn by such objective estimation appeared to be of

low degree. In addition, deficiency of convergence was manifested with binocular dissociation at 8 inches, and diplopia. Otherwise the ocular muscles appeared to have unimpeded motility in the entire field of fixation. When tested for efficiency of monocular perception with both eyes simultaneously — retinal rivalry — while the head and face were kept in straight postural alignment, he seemed to demonstrate incongruity in the quality of uniocular perception. The right eye, but not the left, kept suppressing the images of the testing targets. However, by allowing him to resume his habitual head-face tilting, all the perceptual impediments became spontaneously eliminated. Such vicarious adjustment does not help to permanently eliminate postural deficiencies of the visual apparatus and all dependent functions. It helps to mask them sufficiently to serve immediate needs, while at the same time causing the acquired maladjustments to become intensified and habitual.

The accommodation amplitude and reserves were within normal levels for age.

With Keystone DB 9 cards, at distance the arrow pointed at 9 and at near it pointed at 3. The DB 8C card showed vertical isophoria. Periodic suppression was manifested on Keystone B.U. 5 card. No such manifestation was observed when tested for fusion with Keystone DB 4 and 5 cards, or on Keystone DB 6B, stereoscopic card. Both these functions were normal by these tests. Hole-in-hand experiment showed exteriorization to be of normal quality. It is probable and even possible that the reading defect was part of the conglamoration of incongruities.

Case #8, Mr. M. H. S., Age 22. Visual acuity: right eye 20/20, left eye 20/20, (central or macular vision). This patient had no glasses.

The patient had head tilt toward the left shoulder. When fixating normally, the left palpebral fissure appeared to be narrower than the right. With such patients we look for possible deficiency of the muscles concerned with elevation and with their movements in the vertical and oblique areas of gaze. Here, inspection of muscle action revealed that elevation of the left eye was affected. When the two eyes were elevated simultaneously to the limit of their motility, the left did not reach the same level as the right. In addition, the left eye tended to turn up and inward, while the right fixated in a straight, upward direction.

Tests for determining fusion with Keystone DB 4 at distance and DB 5 at near showed that function to be normal. Yet, tests with Keystone BU 5 and 6 cards showed repeated alternation in fixation with

alternating suppression. However, binocular single vision could be attained by tilting the head, turning the face, or both. When he maintained normal postural adjustment of the head and eyes, the patient showed a tendency to fixate with each eye alternately, suppressing the eye not used.

Muscle functions tested with Keystone DB 9 card showed the arrow pointing at 10 to 11 for distance and at 4 to 5 at near. Vertical isophoria was indicated by the Keystone DB 8C card. Amplitude of accommodation was 8 D. for each eye. Reserves likewise were below normal for age.

The patient has always been essentially ambidextrous, using his left hand for writing and holding eating utensils. In sports he uses his right hand. He is also right-footed and his right eye is dominant. As in other cases reported here, the incongruities and inconsistent findings obtained from tests of the neuromuscular and sensory apparatus may be in this case, partly at least, contributing factors in the reading disability.

Case #9, Mr. N. A., Age 23. Visual acuity: right eye 20/20, left eye 20/20, (central or macular vision). The patient had no glasses. Near vision, smallest size Jaeger type at normal reading distance.

When fixating at near with both eyes simultaneously, the patient had difficulty in maintaining single vision. His near point of convergence was at approximately six inches. At that point there was diplopia and a tendency to right exotropia. The cover test confirmed an insufficiency of convergence. This may have accounted for the asthenopia and supra-orbital and temporal headaches which followed use of the eyes at near. Otherwise there was no apparent abnormality in the performance of the ocular muscles.

The patient is habitually right handed and right dominant. Tests for determining the reciprocal rate in the quality of uniocular performance (retinal rivalry) showed that a disparity existed. In the performance of that test, there was indication of a tendency toward left eye dominance and faulty parallax.

While the accommodation was within normal limits for age, its reserves, adjustment and flexibility were deficient. Such performance tends to indicate that the receded near point of convergence and much of the visual discomfort may be due to strain and exhaustion.

Tests showed absence of suppression. Fusion test on Keystone DB 4 and 5 cards at far point and near was normal. Stereoscopic perception was likewise normal on Keystone DB 6D card.

Convergence insufficiency of the accommodative, or exhaustive type, is suspected as being a contributing factor in anomalies of reading.

Case #10, Mr. R. McK., Age 31. Visual acuity, without glasses: right eye 20/200, left eye 20/200——. With glasses: right eye 20/20—2, left eye 20/20.

Objective testing showed no apparent disturbance in the functional performances of accommodation, convergence or of the vertical muscles. This was attributed by the patient's eye specialist to the special occupational lenses (in bifocals) which this subject was using for all near work. He found them to be of great help. However, testing performance of visual skills by means of instruments and targets, showed some of the functions to be erratic. Thus, tests for estimating the reciprocal rate in the quality of uniocular performance (retinal rivalry) showed that a disparity existed. All tests for dominance except ocular, showed the right side and the right hand to be preferred, but the left eye being dominant. A considerable amount of confusion prevailed during that part of the test. He showed a persistent tendency for ambilateral placement of images from left to right, but he couldn't carry the image over from right to left. Projection also was faulty. It was manifested in the inability to place, project and locate objects in space and to estimate their respective spatial relationships. The Maddox line test was used. Accommodation amplitude was: O.D. 8D; O.S. 10D. Readings with Keystone DB 9 card with his correction were between 6 and 7 at distance and 2 to 2½ at near. All these, together with manifestations of abnormal central (macular) fixation, faulty exteriorization by the hole-in-hand test, and especially disturbance of the fusion faculty at the far point may have been contributing factors to his reading problems.

CONCLUSION

As can be gathered from the clinical data of the case reports, considerable discrepancy was found to exist between the objective tests and those obtained by instrumentation. This, in my experience, is not an uncommon clinical observation. It should serve to teach the clinician and examiner not to depend entirely on stereoscopic instrument tests and not to rely wholly on the readings which are derived from them. Also, that 20/20 vision is no criterion of normal visual performance. It must be foveal or central and be present at all distances tested, for the fusion function to be considered normal.

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THE INCONSTANCY OF THE ACA RATIO*

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INTRODUCTION

The accommodative-convergence accommodation ratio is commonly designated the ACA ratio. The ACA ratio is the change in convergence per unit change in accommodation. It has commonly been designated a physiological constant.[1, 2, 3] Manas and Shulman[4] showed that the variation in the ACA ratio for twenty-two observers was of such magnitude that it was difficult to consider it as a constant. They further derived a relationship between ACA ratio and the nearpoint phoria (No. 13B) which demonstrated the inconstancy of this ratio.

Hirsch[5] in an editorial comment to the Manas and Shulman article stated that only experimental error or observation error had been demonstrated in the measurement of the ACA ratio. He further defined biological constancy as, "A constant function is one which does not change in a systematic fashion."

Utilizing the above definition of biological constancy, an example of constancy would be the glucose concentration of normal plasma. In health, this concentration is maintained between 0.08 and 0.14 per cent, with an average of 0.1 per cent.

An example of biological inconstancy is the basal metabolic rate (B.M.R.). B.M.R. correlates or is significantly affected by height, weight, age, sex, race and activity of the subject.

Thus, when the constancy of a function is investigated, it must satisfactorily pass the following tests: (1) The function must not correlate significantly with any variable. (2) If a group comparison is made, the difference between the means of the two groups must not be significant. (3) Every constant undergoes a certain fluctuation in magnitude due to experimental error of measurement or observation. This variability in the magnitude of the biological constant must not exceed the three-sigma limit of probability. Thus, excessive variation exceeding these probability limits would indicate the inconstancy of the function.

Let us consider the following factors and their effect upon the ACA ratio:

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1. ANATOMICAL AND HISTORICAL

Adler[6] states: "* * * If the ciliary ganglion is removed, however, retrograde degeneration takes place into the Edinger-Westphal nucleus, and by stimulation with the Horsley-Clark instrument it has been proven that this group of cells is connected with pupillary motor activity. No proof has yet been given that this nucleus has to do with accommodation, but the nucleus innervating the ciliary muscle should lie close to the center for pupil constriction, since the two are so closely associated in the near-point reaction." He continues regarding convergence.[7] "The function of Perlia's nucleus is still more indefinite. There is no evidence that it controls convergence, except that already quoted, i.e., the time of its appearance in both the species and in the development of the embryo, which coincides with the positioning of the eyes in the frontal plane where convergence becomes possible. It degenerates when the third nerve is cut, and therefore belongs to the oculomotor nerve, but there is surprisingly little clinical evidence that it is the center for convergence. For the present, this will have to remain an assumption." Figure 1 presents the anatomical relationship

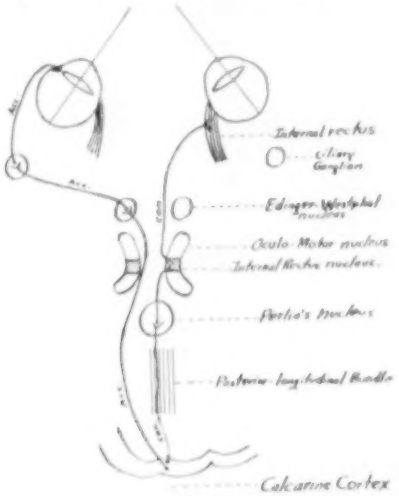

Fig. 1. Innervational Pattern to Accommodation and Convergence After Adler.

of accommodation and convergence after Adler. Thus Adler[8] states, "Convergence is always associated with accommodation and miosis, the collective phenomena being called the 'near-point-reaction.' This is not a reflex in the ordinary sense of the word, but an associated movement or synkinesis." He further states,[9] "The contraction of the pupil

does not depend on either the accommodation or the convergence anymore than does the convergence or accommodation depend upon others of the triad. All three must be looked upon as being associated in a common function. Normally they work together but one may be dissociated from the others. * * *"

Thus, anatomically, the relationship is not a rigid linkage but an associated act to provide single and clear vision for the organism. This association provides that the relationship may vary depending upon physiological, psychological and environmental factors.

2. DEVELOPMENTAL

In the development of the visual apparatus after birth we find that accommodative ability starts first and the development of convergence occurs later. Thus, in the first two years of life, we have a variable association between accommodation and convergence.

3. OCULAR FATIGUE

The mechanism of accommodation functions through a smooth muscle device which is relatively slow acting. The mechanism of convergence functions through a striated muscle device which is fast acting. It is obvious that if these two activities are associated for a common purpose, the effect of prolonged visual activity will result in different rate of change in these two different types of mechanisms and the end result would be a change in the ACA ratio. Stein and Hofstetter[10] found a change in the ACA ratio with prolonged viewing of television, i.e., Subject: G. H., 2.0, 1.0, 3.0, 4.0, 3.0. The range of the change in ACA ratio units for this observer is three units. This excessive change exceeds the experimental error of measurement. This change in ACA ratio, would indicate that the slope of the phoria line is fluctuating between 45 and 76 degrees.

4. PRESBYOPIA

As aging occurs we find that accommodative ability is seriously effected, while convergence ability remains relatively at the same level. We would, thus expect that this one-sided curtailment of physiological functioning ability would result in a change in the ACA ratio with age. Morgan & Peters[11] in testing two hundred presbyopes found a mean value for the ACA ratio of 3.8. They concluded that this mean of 3.8 proved that presbyopes have the same ACA ratio as nonpresbyopes, since the ACA ratio for the general population is 4.0. Unfortunately, the authors did not have a control group in order to prove that under the existing testing conditions that they would have obtained a mean of 4.0 for the nonprebyopes. This is extremely important in dealing with large samples. For example, if the difference between the

means for the presbyopic and the nonpresbyopic groups had been 0.3 ACA ratio units, this difference would have been significant at the five per cent level. That these differences do exist, even when testing large groups, can be seen from the data published by Morgan.[12] In this study, Morgan found an average ACA ratio of 3.64 for a group of 413 nonpresbyopes. If, we again consider that the normal ACA ratio is 4.00; the difference of 0.36 ACA ratio units (difference between the means) is highly significant. A critical ratio of 3.4 is obtained. We must therefore conclude that his clinical group of 413 nonpresbyopes differ significantly from the general population. Thus Morgan has not proven that the mean ACA ratio obtained for presbyopes is the same as the mean ACA ratio for the general population. In fact, we have some statistical indication that the mean of 3.8 for the presbyopic group may indicate a slight lowering of the ACA ratio with age.

Alpern & Hirsch[13] made a statistical analysis of the variation in the ACA ratio (as determined by clinical tests) with age in 1,202 clinical cases, as well as an analysis of haploscopic determinations of the ACA ratio in five individuals over a ten year period. This data indicates a linear relationship between ACA ratio and Age, with the ACA ratio decreasing with age. The equation of this linear relationship is:

$$\text{ACA ratio} = -0.03\ (\text{Age}) + 5.5. \qquad (1)$$

From this equation, we can estimate that the mean ACA ratio at six years is 5.3, decreasing to a mean ACA ratio of 3.7 at sixty years of age. This verifies the common clinical experience of placing stronger plus lens additions on advanced presbyopes with very little effect on the phoria measurement. Thus, there is a relationship between ACA ratio and Age.

5. RELATIONSHIP TO THE NEARPOINT PHORIA

If we consider the formula used by Fry for the calculation of the ACA ratio, we have:

$$\text{ACA ratio} = \frac{15 - \#8 + \#13B}{2.50} \qquad (2)$$

Where, #8 = Farpoint phoria

#13B = Nearpoint phoria at 40 cm.

$$\text{or, ACA ratio} = C_1 - \frac{(\#8 - \#13B)}{C_2} \qquad (3)$$

The magnitude of the farpoint phoria is usually much smaller than the magnitude of the nearpoint phoria. We would therefore expect to find a significant correlation between ACA ratio and the nearpoint phoria. Fry & Haines[14] published in 1940 a scatter diagram of the nearpoint phoria versus accommodative-convergence with 2.50 diopters

of accommodation for one hundred subjects. If we merely divide their accommodative-convergence with 2.50 diopters of accommodation by 2.50, we obtain the ACA ratio. Their scatter diagram with the change in scale has been reproduced as Figure 2. From these data, we obtained

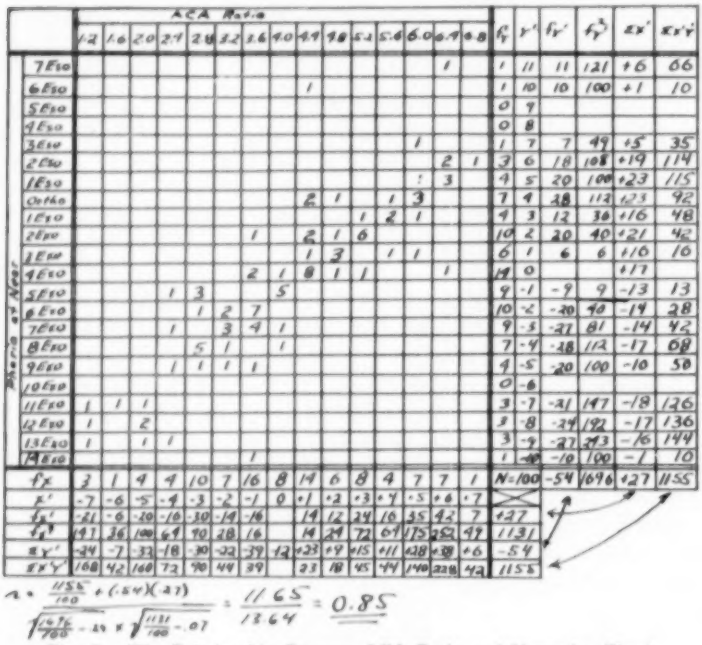

Fig. 2. The Relationship Between ACA Ratio and Nearpoint Phoria After Fry & Haines.

a correlation coefficient of 0.85 between the nearpoint phoria and ACA ratio. This result is very highly significant. Thus there is a relationship between nearpoint phoria and ACA ratio which is highly significant. Further, any test which correlates significantly with the nearpoint phoria will also correlate significantly with the ACA ratio.

6. EFFECT OF VISUAL TRAINING UPON THE ACA RATIO

Morgan[1] states, "* * * some fifty subjects over a period of several years have been given intensive training while some fifty others have been given training but not so intensive. . . . A control group receiving no training was also set up." The author concluded that no significant change, due to training, occurred as far as the Gradient (ACA ratio) was concerned.

Lyle & Jackson[15] in the appendix to their textbook "Practical Orthoptics" list 63 patients with heterophoria who had received visual training. These include: 14 with esophoria, 18 with exophoria and 32 with convergence insufficiency. The authors list the farpoint and nearpoint phoria values for these subjects prior to receiving visual training and after visual training. From these phoria test values, we can calculate the ACA ratio prior to training and after training by the method of Fry. These values are tabulated in Figure 3. The average

ACA Ratio Cell Limits	ACA Ratio Mid-Value	Before Visual Training				After Visual Training			
		f	x'	fx'	fx'^2	f	x'	fx'	fx'^2
-1.5 -1.1	-1.3	1	-11	-11	121				
-1.0 -0.6	-0.8	0	-10						
-0.5 -0.1	-0.3	1	-9	-9	81				
0.0 0.4	0.2	3	-8	-24	192				
0.5 0.9	0.7	4	-7	-28	196	1	-9	-9	81
1.0 1.4	1.2	0	-6			1	-8	-8	64
1.5 1.9	1.7	1	-5	-5	25	0	-7		
2.0 2.4	2.2	4	-4	-16	64	0	-6		
2.5 2.9	2.7	2	-3	-6	18	2	-5	-10	50
3.0 3.4	3.2	4	-2	-8	16	1	-4	-4	16
3.5 3.9	3.7	4	-1	-4	4	1	-3	-3	9
4.0 4.4	4.2	9	0			5	-2	-10	20
4.5 4.9	4.7	6	+1	+6	6	6	-1	-6	6
5.0 5.4	5.2	5	+2	+10	20	19	0		
5.5 5.9	5.7	5	+3	+15	45	12	+1	+12	12
6.0 6.4	6.2	8	+4	+32	128	13	+2	+26	52
6.5 6.9	6.7	4	+5	+20	100	4	+3	+12	36
7.0 7.4	7.2	0	+6			1	+4	+4	16
7.5 7.9	7.7	1	+7	+7	49	2	+5	+10	50
8.0 8.4	8.2	1	+8	+8	64				
		63		-13	1129	63		+19	412

$M_1 = 4.1$
$\sigma_1 = 2.12$
$\sigma_{M_1} = 0.265$

$M_2 = 5.3$
$\sigma_2 = 1.83$
$\sigma_{M_2} = 0.155$

$\sigma_{DM} = 0.307$
$DM = 1.2$
$C.R. = "t" = \frac{1.2}{.307} = 3.9$

Fig. 3. The Effect of Visual Training Upon the ACA Ratio After Lyle & Jackson.

ACA ratio prior to training for these 63 patients is 4.1. The average ACA ratio after training for these same 63 patients is 5.3. This difference of 1.2 ACA ratio units between the means is highly significant. There was also a significant decrease in variability (spread) of the data after training. The above data, with the high critical ratio, indicate strongly that visual training does change the ACA ratio.

7. EFFECT OF AMETROPIA UPON ACA RATIO

Emsley[16] in discussing the effect of ametropia upon the ACA ratio states, "Thus, although the two functions are closely inter-related and controlled by the same cranial nerve, and cannot be voluntarily dissociated except under special experimental conditions, they are not linked together rigidly. They have become associated by hereditary habit. They are brought into action to such relative extents as are required to place both visual axes on the one object and to accommodate for it; in which circumstances the retinal images are on the two foveae and the resulting neural images in the cortex can be fused into a single mental percept. An individual with moderate ametropia apparently grows accustomed to the disparity between the two functions and finds no difficulty in summoning the nervous energy required for the fusion of the two uniocular impressions. His powers of accommodation and convergence develop naturally to deal with the one-sided relationship. A new relationship has to be established when the refractive error is corrected."

In order to determine if ametropia had any influence upon the ACA ratio, two groups of clinic patients were selected at random from the files of Chicago College of Optometry. The first group consisted of one hundred nonpresbyopic patients whose subjective refraction was two diopters of myopia or more. The second group consisted of one hundred nonpresbyopic patients whose subjective refraction was two diopters of hyperopia or more. Using Fry's method of calculation for the ACA ratio, these values were calculated for both groups. The resulting frequency distributions are presented in Figure 4. For the group having two diopters of myopia or more, we obtained a mean ACA ratio of 5.1 with a standard deviation of 2.1. The group having a subjective refraction of two diopters of hyperopia or more, we obtained a mean ACA ratio of 4.0, with a standard deviation of 2.2. The difference, between the means of 1.1 ACA ratio units, is highly significant. Thus, ametropia does influence the ACA ratio.

The myope who is characteristically using less accommodation at near than convergence does develop a higher ACA ratio. The hyperope who is characteristically using more accommodation at near than convergence, does develop a lower ACA ratio. Gibson[17] in defining accommodative convergence states in part, "* * * To see an object situated within infinity clearly and distinctly the eyes must converge and accommodate simultaneously, but the association between the functions is flexible and will vary with the degree of ametropia."

ACA Ratio Cell limits	ACA Ratio mid-value	Myopia of 2.00D or More				Hyperopia of 2.00 or More			
		f	x'	fx'	fx'^2	f	y'	fy'	fy'^2
0.0 – 0.4	0.2	1	-12	-12	144	7	-8	-56	448
0.5 – 0.9	0.7	1	-11	-11	121	2	-7	-14	98
1.0 – 1.4	1.2	3	-10	-30	300	6	-6	-36	216
1.5 – 1.9	1.7	1	-9	-9	81	2	-5	-10	50
2.0 – 2.4	2.2	4	-8	-32	256	7	-4	-28	112
2.5 – 2.9	2.7	3	-7	-21	147	6	-3	-18	54
3.0 – 3.4	3.2	10	-6	-60	360	8	-2	-16	32
3.5 – 3.9	3.7	8	-5	-40	200	9	-1	-9	9
4.0 – 4.4	4.2	11	-4	-44	176	15	0		
4.5 – 4.9	4.7	8	-3	-24	72	6	+1	+6	6
5.0 – 5.4	5.2	6	-2	-12	24	8	+2	+16	32
5.5 – 5.9	5.7	8	-1	-8	8	7	+3	+21	63
6.0 – 6.4	6.2	14	0			7	+4	+28	112
6.5 – 6.9	6.7	2	+1	+2	2	2	+5	+10	50
7.0 – 7.4	7.2	7	+2	+14	28	2	+6	+12	72
7.5 – 7.9	7.7	3	+3	+9	27	0	+7		
8.0 – 8.4	8.2	5	+4	+20	80	2	+8	+16	128
8.5 – 8.9	8.7	2	+5	+10	50	1	+9	+9	81
9.0 – 9.4	9.2	1	+6	+6	36	1	+10	+10	100
9.5 – 9.9	9.7	0	+7			1	+11	+11	121
10.0 – 10.4	10.2	1	+8	+8	64	0	+12		
10.5 – 10.9	10.7	1	+9	+9	81	1	+13	+13	169
		100		-225	2247	100		-35	1953

$M_{Myopia} = 5.1$ $\quad M_{Hyper} = 4.0$

$\sigma_{Myopia} = 2.1$ $\quad \sigma_{Hyper} = 2.2$

$\sigma_{M_M} = 0.21$ $\quad \sigma_{M_H} = 0.22$

$\sigma_{0.66} = 0.31$

$\text{Critical Ratio} = \text{"}t\text{"} = \frac{1.1}{0.31} = 3.55$

Fig. 4. The Effect of Ametropia Upon the ACA Ratio.

8. CLINICAL EXPERIENCE

It is a common clinical experience to find considerable fluctuation in the ACA ratio upon periodic retesting. The statistical problem arises, what amount of fluctuation can be expected due to instrumentation and observational errors, and what magnitude of fluctuation would indicate a change in ACA ratio which in all probability is due to some outside factor. This is the statistical technique used in quality control. In order to apply this technique to our problem, we must determine the mean and standard deviation of the ACA ratio for a particular individual for a number of trials. To obtain statistical significance, these periodic testing units must consist of at least four determinations of the ACA ratio and these should be repeated for at least ten periods. Using this procedure (Quality Control[18]), we calculate an overall mean and standard deviation for our subject. From these data, we can determine the control limits for each statistic (mean and standard deviation). These control limits are calculated on the basis of three standard devia-

tions. Thus, the variation from period to testing period which stay within these control limits are in all probability due to errors of instrumentation or observation. However, all those values which are equal to the control limit values or greater in magnitude, indicate with a high probability (997:3), that our subject has varied significantly from the mean value and this variation is indicative of some outside or assignable cause.

For two observers, the ACA ratio was determined by a modification of the Morgan method of direct determination. The nearpoint phoria was measured on a Troposcope. A 20/20 nearpoint letter "E" target was used. To obtain dissociation one housing of the Troposcope was raised three prism diopters and the other housing was lowered three prism diopters. The subjects were instructed to keep the upper "E" target clear at all times and to report the appearance of any blur. If any blur was reported, those values were rejected and the test repeated. The nearpoint phoria was taken through —1.00 diopter spheres and then repeated through +1.00 spheres. If subject had any subjective correction this was considered. Thus the change in convergence was measured for a two diopter change in accommodation. Dividing this convergence change by two, gave us the needed ACA ratio. At each testing session these measurements were repeated four times. For observer S, fifteen of these testing sessions were obtained (Total of 60 measurements); for observer R, sixteen testing sessions were obtained (total of 64 measurements). All of this testing was uniformly distributed over a five-week period and was performed at the same time of the day.

The mean ACA ratio for subject R is 1.7 with a standard deviation of 0.29. The mean ACA ratio for the upper control limit[18] is:

$$\text{ACA ratio} = 1.7 + 1.88\ (0.29) = 2.3. \qquad (4)$$

The mean ACA ratio for the lower control limit[18] is:

$$\text{ACA ratio} = 1.7 - 1.88\ (0.29) = 1.1. \qquad (5)$$

For subject "R," the upper control limit for the standard deviation[18] is:

$$\text{Standard deviation} = 2.33\ (0.29) = 0.68. \qquad (6)$$

For subject "S," we have a mean ACA ratio of 3.8 and a standard deviation of 0.56. For the mean ACA ratio, the upper control limit[18] is:

$$\text{ACA ratio} = 3.8 + 1.88\ (0.56) = 4.9. \qquad (7)$$

The lower control limit for the mean ACA ratio is:

$$\text{ACA ratio} = 3.8 - 1.88\ (0.56) = 2.7. \qquad (8)$$

For subject "S," the upper control limit for the standard deviation[18] is:

$$\text{Standard deviation} = 2.33\ (0.56) = 1.3. \qquad (9)$$

The control limits and data for subject "R" have been entered in Figure 5 and the control limits and data for subject "S" have been entered in Figure 6. For Subject "R" (Figure 5), we note that of the total of sixteen testing periods over the five-week period, eight testing

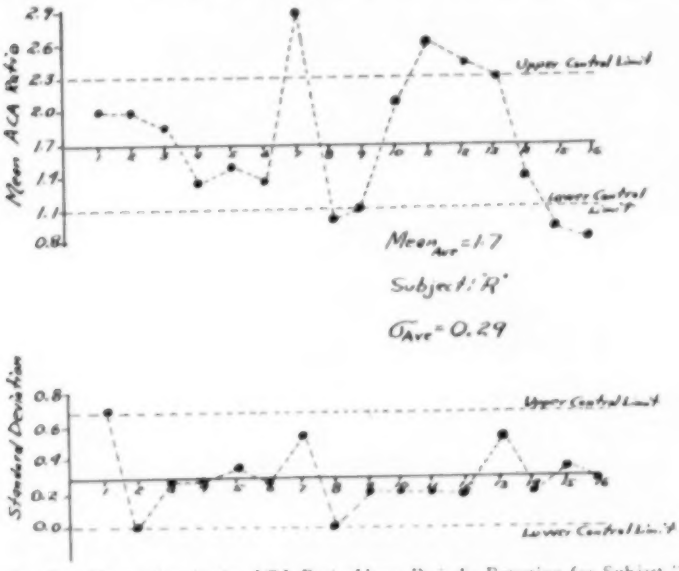

Fig. 5. The Fluctuation in the ACA Ratio Upon Periodic Retesting for Subject "R."

periods gave a mean ACA ratio which deviates from the overall mean ACA ratio by a significant amount. Therefore these changes in the ACA ratio cannot be dismissed as being due to errors of observation or instrumentation. For the subject "S" (Figure 6), we note that of a total of fifteen testing periods, four of these testing periods gave a mean ACA ratio which differed significantly from the overall mean ACA ratio. These data, for these two observers, corroborate our clinical experience in the significant variations in ACA ratio which occur with time and which are most likely due to changes in the internal or external environment of the patient.

SUMMARY

It is the contention of the author that the premise of the inconstancy of the ACA ratio is sustained on the basis of:

1. Anatomically, the relationship is of such a nature as to give flexibility to the relationship between accommodation and convergence.

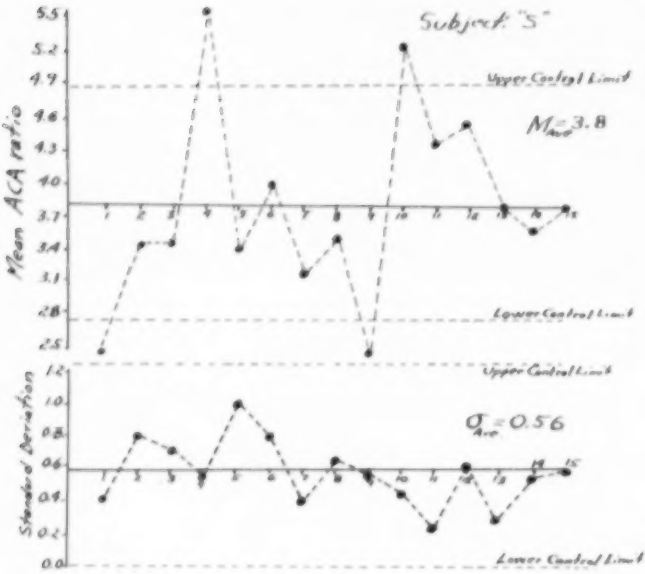

Fig. 6. The Fluctuation in the ACA Ratio Upon Periodic Retesting for Subject "S."

2. From a developmental viewpoint, we find that the rate of development of these two components is different and thus we must have two flexible mechanisms rather than a rigid relationship.

3. Since the accommodative mechanism works through a slow acting mechanism and the convergence mechanism functions rapidly, it becomes essential that a flexible relationship between accommodation and convergence be maintained.

4. There is a relationship between age and ACA ratio.

5. There is a highly significant relationship between the induced phoria at near and the ACA ratio.

6. Visual training does produce a significant change in the ACA ratio. Visual training tends to increase the ACA ratio.

7. It was found that ametropia influences the amount of the ACA ratio. Myopes tend to have a higher ACA ratio than the hyperopes.

8. Periodic retesting of two subjects over a five-week period revealed that the ACA ratio did at times fluctuate significantly from the overall mean value of the ratio.

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CLINICAL NOTES ON THREE CASES OF PARALYSIS OF CONVERGENCE*

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Paralysis of convergence is not uncommon and the only reason for reporting the three cases to follow is to show how easily it can be overlooked.

In the following cases, one patient had been treated at several hospitals and stated that at one hospital the attending physician advised an operation to correct his ocular muscle condition. When one considers the complexity of the extra-ocular muscles, it is readily understood why incorrect diagnoses are frequently made.

Too much emphasis cannot be laid upon the importance of the Wassermann test as an aid in diagnosing pathological ocular deviations whether the condition is due to an involvement of one or more of the extra-ocular muscles. This test or the Hinton test is a *must* in all cases manifesting a possible paralysis of eye muscles. The fact that two of the three patients now being reported had positive Wassermann reactions, suggests that we ask ourselves the following questions: (1) Whether or not we are dealing with a lesion of syphilitic origin, the manifest symptom of which is paralysis of convergence? (2) If such is a common symptom found in syphilis and is being overlooked? (3) Is it an early or late manifestation of syphilis?

Case 1. H. B. Age 41, Negro. Male. First seen on March 30, 1951, on complaint of diplopia at near. Past history of rheumatism three years ago. Venereal disease denied. Present difficulty started three years ago following an attack of rheumatism. Diplopia more marked at present.

Examination: Vision O.D. 20/100 correctable to 20/20 with +0.50 D. sph. ⌒ +0.75 D. cyl. axis 90. Vision O.S. 20/70 correctable to 20/20 with +0.75 D. sph. ⌒ +0.50 D. cyl. axis 90.

External examination, negative throughout.

Fundi, normal, media clear.

Pupils react normally to light directly, indirectly and to accommodation.

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Near point of accommodation 22½ cms., right and left.
Extra-ocular muscles, associated movements normal in all fields. No paralysis of individual muscles.
1½Δ exotropia at distance and 14Δ exotropia at near. (13 inches)
Tangent screen showed crossed diplopia in the primary position, not increasing in any other field.
Patient unable to converge to the slightest degree.
Neurological examination: Negative except for some suspicion of inequality of knee-jerks.
X-ray for skull and para-nasal sinuses, negative.
Blood Wassermann, positive.
Diagnosis, paralysis of convergence of syphilitic origin.
Treatment, elimination of syphilis with partial recovery of convergence function.

Case 2. M. P. B. Age 22. Negro. Male. First seen April 8, 1952. Patient constantly annoyed with diplopia at near. Family history negative. Patient's past history, negative. Venereal disease denied. Present difficulty dates back seven years, at which time patient suddenly noticed that everything he looked at appeared double. Condition has progressed very slowly.
Examination: Vision O.D. 20/20 negligible refractive error. O.S. 20/20 negligible refractive error.
External examination, negative throughout.
Fundi, negative, media clear.
Pupils react normally to light, directly and indirectly, and to accommodation.
P. P. of accomodation 12 cms., right and left.
Extra-ocular muscles, orthophoria at distance. 7½ exotropia at 13 inches.
Associated eye movements in six cardinal directions, normal in extent.
Tangent screen showed crossed diplopia in the primary position, remaining the same in all other fields.
Neurologic examination: negative except for some inequality in knee jerks.
X-ray, skull negative and para-nasal sinuses negative.
Blood Wassermann, positive.
Diagnosis, paralysis of convergence of syphilitic origin.
Treatment, elimination of syphilitic condition with partial recovery of convergence function.

Case 3. A. E. L. Age 46. Caucasian. Male. First seen April 7, 1953. Patient complains of double vision at near. Family history

negative and non-contributory. Patient's past history of no consequences. Venereal disease denied. Present difficulty started three months ago when he began seeing double at the near point.

Examination: Vision O.D. 20/20 negligible refractive error. Vision O.S. 20/20 negligible refractive error.

Accepts O.U. +1.25 D. sph. for near work.

Pupils react normally to light, directly and indirectly, and to accommodation.

External examination, negative throughout.

Fundi, negative, media clear.

P. P. of accommodation 29 cms. right and left.

Orthophoria at distance.

7½ degrees of exotropia at 13 inches.

Associated movements of eyes normal in six cardinal directions indicating no paralysis of individual muscles.

Tangent screen showed crossed diplopia in primary position, remains the same degree in all other fields.

X-ray of skull and para-nasal sinuses, negative.

Blood Wassermann, negative.

Diagnosis, paralysis of convergence of undetermined origin.

Treatment, high frequency diathermy, with partial recovery of the convergence function.

ERRATA

In the October, 1954, issue of this journal in an article, "The effect of veiling luminance upon the apparent brightness of an object" by Glenn A. Frey and Mathew Alpern, the following corrections should be made:

Equations (12) and (14) should read as follows:

$$H = k_7 \int_0^{\infty} \int_0^{2\pi} \gamma(\rho)\, w\, \rho\, d\varphi\, d\rho \qquad (12)$$

$$k_8 = \pi\, k_7 \int_0^{\infty} \gamma(\rho)\, \rho\, d\rho \ . \qquad (14)$$

The second sentence in the second paragraph on page 507 should read as follows:

The beam splitting prism, C, permits the right eye to see, etc.

CONTACT LENS RESOURCES*

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Contact lens science has made such significant advances in recent years that the resources of those who correct vision by this means have been greatly augmented. Although contact lenses still replace glasses only part of each day, as a rule, the hours of acceptable wear have been so increased and the percentage of patients who can achieve comfort without severe effort is so much greater than in the past that contact lenses have been advanced to new levels of success and usefulness. Today there are few patients who, if they exert fair persistence, cannot wear successfully for many hours each day the type of contact lens best suited to them. All-day wear is increasingly frequent.

The recent advances have in large measure resulted from the development of several relatively new types of contact lenses. As with all progressive sciences, the more that can be accomplished, the more complex the science becomes. Today there are at least thirteen significantly different forms of contact lenses, each one functioning better than any other on certain cases. Since every contact lens patient is entitled to the best type of lens for his particular needs, as well as the best fit of the optimum type, it will be well worth while to outline and systematize the many resources which are currently available.

Contact lenses, first suggested by Leonardo da Vinci,[1] are today divided into two main categories, each with several sub-categories. The main divisions consist of corneal contact lenses, which cover at least the optical zone of the cornea, and scleral contact lenses, which cover most of the anterior segment of the eye.

CORNEAL LENSES

Corneal contact lenses are the smaller and simpler of the two main types and also the least costly as a rule. Hence they are quite popular, even though somewhat more difficult to get used to. Their principal limitation arises from the sensations produced in the upper lid lining

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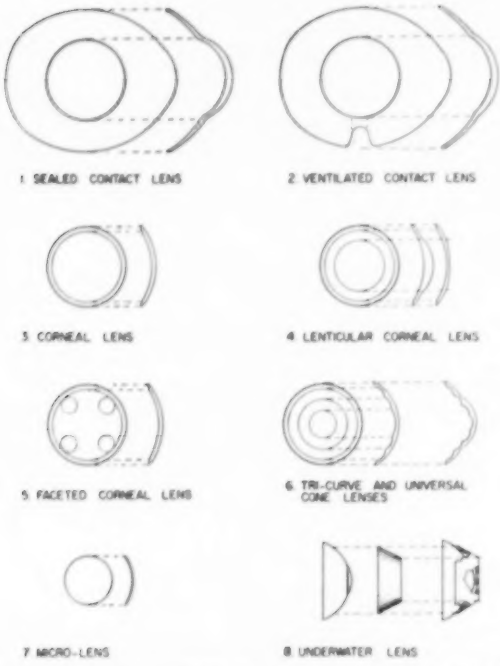

as it slides across the upper edge of the lens during blinking. These sensations are slight and superficial, and not due to interference with blood flow, tear circulation, or ocular metabolism. Hence the wearer usually adapts to them and can ordinarily forget by the hour that the lenses are in place. However, the lenses usually arouse more noticeable sensations after several hours of wear, and then may become annoying enough to lead to their removal at least temporarily. Adaptation to the lid sensations is accomplished by wearing the lenses for longer periods each day. Persistence on the part of the wearer is called for if long wearing time is to be achieved.

A secondary limitation of corneal lenses arises from the fact that, while they are secure enough for most purposes, they do not stay in position so securely as the larger lenses. Corneals are rarely lost—as evidenced by the fact that they are insurable for a very modest amount—but they are not usually secure enough for football and other violent sports. It can be judged that those who require maximum security of the lenses, or maximum protection of the eyes, as well as those with tense lids or hypersensitive lid linings, are not best served with regular

corneal lenses: neither, as a rule, are those with extreme corrections, or with gross amounts of astigmatism.

TUOHY CORNEALS

Among the types of corneal lenses available are the original Tuohy lenses,[2, 3] as well as others essentially similar to them. These consist of simple spherical front and back surfaces, with the back surface exhibiting a narrow bevel around the edge. (See Figure 3.) Some of these lenses are manufactured in a rather haphazard manner. Others are of excellent quality and precise manufacture. Some wearers can tolerate wide deviations from the optimum fit. However less tolerance is required of the patient, and the wearing time is longer, when the lenses are exact as to manufacture and fit.

FACETED CORNEALS

In addition to the original corneal lenses with spherical back surfaces, there are available lenses with faceted ocular surfaces. (See Figure 5.) The facets are intended to relieve some of the pressure of the lens against the corneal apex, and possibly augment the tear flow across the apex of the cornea. They are a successful type of corneal lens and in some instances prove to be more secure and tolerated better than spherical corneals.

TORIC CORNEALS

Also available, for corneas with more astigmatism than the average, are astigmatic corneal lenses. The toroidal back surfaces of these conform more closely to the toroidal contours of astigmatic corneas, and often the gain in comfort and security is good. In some instances this is the only type of corneal lens which will ride securely upon the eye.

If the toroidality of the cornea and its lens is sufficient to prevent the lens from torting (greater than 2.00 D.), a correction for astigmatism can be incorporated into this type of corneal lens when necessary.

LENTICULAR CORNEALS

Corneal lenses of lenticular construction are so superior to regular corneals on many cases with strong corrections that they justify classification in a sub-category of their own. This is particularly true because they perform differently than identical but non-lenticular lenses.

On strong minus lenses a bevel of different radius surrounds the central area of the front face. (Figure 4.) Only the central area carries the correct power. This permits a substantial reduction in edge thickness, to the greater comfort of those with strong corrections for myopia. Also, whenever a contact lens is used as the eye-piece of an ophthalmic telescope for subnormal vision, it is made lenticular so as to increase the amount of minus power which can be worn on the eye.

Similarly, in lenticular plus lenses, only the central zone carries the prescription, with the result that the lens is much thinner than if it were of conventional construction. (Figure 4.) Lenticular corneal lenses for post-cataract cases are among the most successful of contact lenses. They are easily worn, and the size of the retinal image is so nearly the same as before removal of the cataract that patients do not undergo the difficult reorientation called for by thick cataract glasses. Even monocular aphakics with useful but dissimilar images in each eye usually achieve binocular fusion at once with lenticular corneal lenses.

TRI-CURVE CORNEALS

For conical corneas in which the conus is of moderate degree (incipient keratoconus), tri-curve corneal lenses often represent the design of choice. The back surfaces of these lenses exhibit three concentric zones, the center one of shortest radius, the peripheral zone of longest radius (Figure 6). Considerable choice as to radii is available. Such a construction permits closer conformity of the lens to conoidal corneae, and results in a more secure and comfortable fit. On certain conical corneas this type is the only corneal lens which will stay in place. When a cornea is irregular, the visual acuity achievable with corneal lenses is often even better than it is with scleral contact lenses.

Evidence is accumulating that corneal lenses on cases of keratoconus may arrest or retard increase of the conus. In some instances they even seem to reverse the process by flattening conus, at least temporarily.

UNIVERSAL CONE LENSES

An extension of the tri-curve principle to accommodate pronouncedly conical corneas results in lenses with four or more concentric zones on the corneal contact side. Such lenses are referred to as universal cone lenses. (Figure 6.)

MOLDED CORNEALS

When corneal lenses are strongly indicated (as in keratoconus), yet trial case corneals, including the multiple curve types just described, are not sufficiently secure or comfortable, an impression of the cornea and limbus may be taken and a molded corneal lens made for that particular eye. This procedure will sometimes provide a degree of comfort and security not achievable on such cases with any other corneal lens.

MICRO-LENSES

The smallest and least visible of all contact lenses are the micro-lenses—tiny menisci of clear plastic which are not more than 0.25 mm.

thick and average about 9.5 mm. overall. (Figure 7.) If made much thinner they become too sharp at the edge and too flexible; if much smaller the edges tend to encroach too much on the visual field. The developments in micro-lenses are currently the most dynamic in the entire contact lens field. These little lenses are far from perfect—the best laboratories still cannot always duplicate lenses to exact specifications, hence fitting is often frustrating. Yet, even in their present state of development, they constitute a valuable addition to contact lens resources. Micro-lenses already stand as one of the major advances in contact lenses. Essentially they are merely a diminutive corneal lens, lacking even a bevel in most cases. Yet, since they interfere less than any other contact lens with the natural condition of the eye, they give gratifyingly better performance, on many wearers, than any other kind.

SCLERAL CONTACT LENSES WITH FLUID

In the relatively recent past, scleral contact lenses which held a fluid pool against the cornea were widely used, being the first type developed and practically the only one available for some time. (Figure 1.) Such lenses are seldom fitted today. They are bulgy and the stagnation of the sealed-in fluid results in corneal edema and temporary clouding of vision too soon after insertion of the lenses. Nevertheless, such lenses are still indicated when the cornea must not be touched. This may be a requirement when the cornea is badly scarred or exhibits latent or active pathology. This is the lens rated by the Army as best of all those tested for swimming and diving.[4] It is fitted by taking an eye impression—the technique used preponderantly since Dallos introduced the molding technique—or, less often, by trial case procedures.

FLUIDLESS MINIMUM-CLEARANCE SCLERAL CONTACT LENSES

If corneal lenses had never been devised we could still be proud of the progress in contact lenses because of the advances in scleral contact lens types. No longer need scleral contacts bulge unbecomingly. No more need corneal clouding soon terminate the wearing time each day. Corneal lens fluid and all its attendant problems are practically done away with.

No other contact lenses are so safe, secure and comfortable to wear as present-day minimum-clearance lenses. No others are so versatile. Corrections for high ametropia, including strong spheres, cylinders and prisms, all are manageable in minimum-clearance lenses. No other type is so easy to get used to. This is the type rated by the U. S. Army as best of all those evaluated, under most conditions of their

tests. In the words of the Army report:[4] "It is concluded that a vented, fluidless scleral lens that permitted free flow of tear fluid and aeration of the cornea was superior to other designs." It should be added that the Army's criteria are not exactly the same as civilian criteria and that the Army did not test micro-lenses. Nevertheless, their tests are the most definitive to date. The Army report also points out that minimum-clearance lenses are the most time-consuming to fit. Hence they are usually a more expensive type than corneals.

Minimum-clearance lenses differ from their predecessors in riding so close to the cornea that there is not room for an air space (bubble) between the corneal apex and the contact lens. Hence these lenses need not be sealed so as to retain fluid. This eliminates the occurrence of negative pressure (suction) on the eye and allows the lens to be of such construction that fresh tears and air can readily enter and leave the pre-corneal chamber. Consequently the corneal clouding which occurred in the older (fluid) lenses is almost completely avoided. The newer lenses, having a condition of minimum clearance, seldom require artificial fluid. A capillary layer of natural tears fills the narrow space between lens and eye. These lenses must not touch the cornea other than fleetingly or irritation soon ensues. Definite pressure on the cornea from this type of lens may induce folds in Descemet's membrane, and sometimes temporary disturbances of vision. Minimum-clearance lenses must clear the corneal apex by about 0.07 mm. This is a most critical dimension and is particularly difficult to arrive at because the lens tends to settle onto the eye for some weeks after the fitting. Allowance for settling must be made at the time of fitting. If the lenses should settle so as to contact the cornea, the interior optical surface must be ground away sufficiently to relieve the touch.

Some minimum-clearance lenses are vented (fenestrated), with one design (Lacrilens) having large ports or inlets at top or bottom or both. (Figure 2.) These ports are hidden by the lids and connect with the pre-corneal chamber by means of channels in the back surface of the lens. Such construction permits ingress and egress of tears to this chamber. Other modifications of this type utilize small perforations in the exposed parts of the limbal area. These apertures are too fine to be seen or felt during wear, yet through them air, tears and metabolites circulate with the turning of the eye. All of the scleral types described above are made from individual impressions of the eyes to be fitted. Other types are fitted from trial cases. Of these the Mueller-Welt lenses depend on a loosely fitted scleral flange to permit circulation of air and tears. Another type (Para-Sclerals) utilizes raised islands as the prin-

cipal scleral contact areas. Tears may flow around and between these islands as the eye looks about.

All lenses described thus far in this report are made of plastic. An interesting variation of the above is a vented glass minimum-clearance lens. For those with an allergy to plastics, or whose tears will not wet and lubricate plastics adequately, these are the type of choice.

TINTED CONTACT LENSES

Plastic contact lenses may be made of tinted material or, alternatively, may be tinted after manufacture. Tints may be blue, hazel or brown to match the iris and are more often required by lightly pigmented individuals than by others. The need for tint is greater with corneal lenses than with sclerals, for photophobia is more frequently encountered with corneals. In tinting scleral contact lenses, only the area over the iris is colored. The principal limitation of tint lies in the fact that, if much color is used, it cuts out too much light indoors, or during the evening. It is, of course, always possible to have one pair tinted and one untinted. However, plano sunglasses over contact lenses are usually the approach of choice, being more easily put on or off. off.

Tint is not available in glass lenses and is rarely used in micro-lenses because the little lenses cover only a part of the cornea. If colored, micro-lenses usually produce an unnaturally darkened area on the iris.

COSMETIC CONTACT LENSES

It is but a step from tinted contact lenses to cosmetic contact lenses. The pale blue of some eyes can be deepened and enhanced by wearing slightly blue contact lenses. Light brown, mottled, or indifferent irises can be made darker and more attractive by the wearing of brown contact lenses. Blue eyes can even be made into brown eyes by the same simple means.

It is more difficult, however, to make brown eyes blue or grey. To accomplish this, an artificial iris of the desired color must be imbedded into the contact lens, so as to obscure the darker iris beneath. The pupillary area must remain optically clear and carry the prescribed power.

It is often a matter of great nicety to get a colored corneal lens, or the colored part of a scleral lens, to coincide exactly with the iris itself. However, the effect is often well worth the effort demanded of the fitter, especially if it makes the patient more photogenic, or equalizes two irises of different coloration.

ARTIFICIAL PUPIL

It is only one further step from a contact lens with an artificial iris for cosmetic purposes to one with an artificial iris for optical pur-

poses. In cases of aniridia, of damage to the iris, of iris detachment at the edge, or of albinism, the iris deficiency can be overcome by employing a contact lens carrying a fused-in iris. Where a pinhole spectacle is required, it can often be best supplied in a contact lens,[5] with minimum restriction of field and without the bizarre appearance of regular pinhole spectacles.

CONTACT LENSES FOR UNDERWATER SEEING

A type of contact lens has been elaborated to permit maximum visual acuity whether the wearer is above water or beneath the surface. The lens consists of a standard scleral contact lens, over the front of which is fitted a small truncated cone of clear plastic. The base of the cone meets the scleral part of the contact lens tangentially, and is set into it to form a juncture which is smooth to the lids. The tops of the truncated cone is covered with a flat disc of thin plastic (Figure 8). This then serves as a diminutive diver's face-plate, and maintains at all times a small air space before the anterior surface of each contact lens. Thus the power of the contact lens is never neutralized by water when the lens is submerged. The result is vision as clear as with any submarine face plate (clearer if the wearer needs correction), and with several advantages over the usual skin-diver's or frog-men's face mask. Leakage, fogging due to moisture condensation, dislodgment by waves, restricted field, all are obviated. Such lenses are the least comfortable and least attractive of all contact lenses, and are many times more expensive than the simple face mask which they replace. Nevertheless, the improved performance justifies them in certain cases, particularly if the swimmer needs visual correction. These lenses were developed at the University of California for the Navy Department of Underwater Warfare.[6]

CONCLUSION

The above discussion includes only the thirteen principal variations in contact lenses currently in use for the correction of vision. Purposely omitted are contact lenses for gonioscopy; electrode contact lenses for making electro-retinograms; lead contact lenses to protect the globe during X-ray exposure; cosmetic contact lenses without optics; etc.

The introduction of contact lenses of advanced and varied design has substantially increased the degree of success which can be achieved by those who justifiably wear contact lenses. By making contact lenses easier to master, it has reduced the amount of ametropia which must be present in order for adequate motivation to exist.

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TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization d ta news, professional problems and ideals, as these relate to the Academy.

TEXAS ACADEMY OF OPTOMETRY

The newly formed Texas Academy of Optometry, a Chapter of the American Academy of Optometry, held its first meeting in Houston, April 17. Dr. Bernard Mazow, Houston, was elected chairman. Dr. Ira E. Woods, Littlefield, vice-chairman and Dr. Darrell B. Carter, Houston, secretary-treasurer. The officers and Dr. O. Reynolds Young, Dallas, and Dr. Nelson Greeman, San Antonio will serve as the executive council. In December, 1956, the annual meeting of the American Academy of Optometry will be held in Houston.

NEW YORK ACADEMY OF OPTOMETRY

Dr. Earl Taylor, director of the Washington Square Reading Center, New York City, was the speaker at the May 17, meeting of the New York Academy of Optometry. The meeting was held at the Midston House.

ACADEMY LUNCHEON AT MILWAUKEE

All Academy members are urged to attend the 58th Annual Congress of the American Optometric Association in Milwaukee, July 6-9. A special Academy luncheon is scheduled for Friday noon, July 8, at the Schroeder Hotel. Members and guests are urged to attend this Academy summer luncheon. Dr. Morton Abram, Chicago, is arrangements chairman.

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WE DRIFT INTO A PERIOD OF SUSPICION AND DISTRUST

The relationships between optometry and ophthalmology, as viewed over the years, must be extremely puzzling to the average practitioner in these fields who has learned that he has no difficulty at all in getting on nicely with a nearby ophthalmologist or optometrist as the case may be. To these men who read of the reported organizational conflicts between the groups, or who are informed of the legislative battles for some fancied advantage, these interprofessional upheavals must seem strange indeed, and we suspect the rank and file of practitioners in both groups could do nicely without them.

Why then, are the relationships between optometry and ophthalmology subject to such violent fluctuations and why does it seem that just when things are going smoothly that something always happens to start more trouble?

The answer is simpler than most people realize. It is contained in the one word—selfishness. To be sure, one may list dozens of individual incidents, each of which seems to irritate some particular group. But even when this has been done, and the list is studied, the fact remains that professional selfish interest, by one group or the other, is usually at the root of the incident.

Instead of working towards solutions that would be of best interest to the public we all serve, those who have been charged with conferring on mutual professional problems are too often forced to follow "party-lines" that frequently ignore fine ethical principles, just to serve expedient power politics.

Optometry is not alone in this. Ophthalmology is equally guilty, and opticianry, too, has contributed much, in recent months, to help confuse what is right from what is politically and financially convenient. All groups are thus to blame and each in many ways must share the censure that is sure to come as the result of the current rumpus.

At this point in the discussion someone always points out that the same sort of disputes take place periodically between trade groups—between labor and management—or one country and its neighbor and that on the world stage the current East-West friction is but a manifestation of the same thing—this being the expression of selfishness at merely a higher political level. But pointing this out explains nothing at all, nor does it excuse for a moment what is happening. In all this welter of friction, what is basically fine and good is usually lost sight of, for the personal gain or glory of some particular group.

This editorial is being written late in May. During the coming June the American Medical Association will meet in Atlantic City. Early in July the American Optometric Association will meet in Milwaukee. At both of these meetings some tempers will run high and much inflammatory material will be placed before the delegates. What will happen then is anyone's guess—we may only hope that at both meetings the cooler heads will be heard and their suggestions followed. We must remember that in a year or two, the issues of today will be forgotten—but irrational political actions, taken in anger, may live to plague us all for another generation.

And what may be done? Well, an answer is that we as optometrists should first set the good example. We are the numerically large group in the eye care field. We do most of the refractive work. We will continue to do this work as long as we do it well and as long as we continue to have the best interest of the patient at heart. That philosophy must motivate our every action—in our offices—in our local professional

groups and above all in those discussions made collectively at our national meetings.

By acting unselfishly, and by setting the proper example, we will in time attract similar reactions from those who manage the affairs of ophthalmology and opticianry.

I am well aware that many self-sufficient practical optometrists will doubt such a philosophy and some may even sneer at it, yet, its the only avenue open to us in the long run and it certainly is the sure way which will consistently give our patients the health service they should have. I can think of no other suggestion. Certainly smart political maneuvering will not suffice, as sooner or later those who are tricked, will turn the tables.

And what will be the outcome of the present trouble? Well—it may be unpleasant for a time, but things have a habit of quieting down—even professional rabble-rousers can not keep a show going indefinitely—and when things do quiet down and when the groups that are involved finally get a good look at the trivia that are now used to cause the commotion, the individuals responsible will probably be discredited.

Over the years, at the practitioner level, the professional relationships between optometrists and ophthalmologists have been good. These are the rank and file practitioners who keep the visual health problems of millions of patients in their hands. These good relationships will continue in a large part, as these men are not our demigods and they seek no commendation in championing "causes." And, these are the men that in time will again insist that the peace makers among us sit around the table in yet another effort to bring together in greater harmony all elements at the strictly organizational level. Events have a habit of repeating themselves.

And so, as we drift into another period of suspicion and distrust, let us remember that this turmoil is largely on the surface—at the top political level—and that beneath the disturbance lies the true spirit of public service that runs deep throughout both optometry and ophthalmology. So, in any event, irrespective of what others may do, let us keep our heads and remember that as optometrists we have only one mission—and that is the protection of the nation's vision. Let all of our actions be toward the attainment of this goal.

CAREL C. KOCH

CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

ILLINOIS COLLEGE OF OPTOMETRY

The new Illinois College of Optometry became a reality on May 25 when the Board Chairmen of Northern Illinois College of Optometry and Chicago College of Optometry signed the consolidation papers as authorized by their respective Boards of Trustees in April. Dr. Glenn H. Moore, Chicago, former chairman of the Board of Trustees of NICO signed for his Board, and Dr. Eugene W. Strawn, Freeport, Illinois, former chairman of the Board of Trustees of CCO signed for his. These consolidation ceremonies took place at a joint meeting of faculty, school officials and students on the campus at Illinois Tech.

For the new Illinois College of Optometry, Dr. Moore has been elected chairman of the Board of Trustees and Dr. Strawn has been elected president of the College.

Dr. Richard Feinberg has been elected vice-president and Dean of Illinois College of Optometry and Dr. Morton Abram has been elected vice-president in charge of business administration.

The consolidation of the physical plant will take place during the summer and all faculty and undergraduate students will be united on one campus when the Fall semester opens in late September.

Under the direction of Dr. John R. Kennedy, St. Paul, president of the NICO Alumni Association and Dr. Strawn representing the Alumni Association of CCO, the two associations will also be merged at a special meeting in July of this year. Mrs. Margarite McNally, will serve as Secretary of the new Illinois Alumni Association.

FREEMAN TO SPECIALIZE FULL TIME IN CHICAGO

Dr. Eugene Freeman, Chicago, Dean of Chicago College of Optometry since 1947 has resigned from the college faculty to devote all of his time to his private practice at his office 1201-1202 Willoughby Tower, 8 South Michigan Avenue, Chicago.

For years Dr. Freeman has been one of the leading contact lens specialists in the mid-west. He is a Diplomate of the Contact Lens Section of the American Academy of Optometry and has contributed greatly to the moulded and trial-case contact lens fitting techniques.

In addition he has made important contributions to the clinical development of sub-normal visual aids. Just recently he completed a study of nearly two hundred sub-normal vision cases that he has fitted with the new Feinbloom telescopic spectacles.

His work has contributed much to the development of these specialities and the technical papers he has presented have served greatly to enrich the literature.

Dr. Freeman's practice is, in great part, a specialists' consultant practice. Cases requiring unusual visual aids are referred to him by his many optometric friends from all parts of the country. The referring optometrist and Dr. Freeman then work out the patient's unusual problems together. Those optometrists who practice within 500 miles of Chicago are fortunate in having Dr. Freeman as a full time consultant in these fields to whom they can refer their most difficult subnormal vision and contact lens patients. We of the Journal staff wish him success in his new full time practice.

CAMPUS NOTES

Dr. Henry A. Knoll, Dean, Los Angeles College of Optometry, tendered his resignation effective June 30, 1955. The resignation has been accepted by the Board of Trustees of the College with regret. . . . Dr. Frederick Kushner, Dean, of Northern Illinois College of Optometry since 1952, has resigned from the College faculty to practice optometry with Dr. J. J. Brady at Sheldon, Iowa. Dr. Brady is a member of the Board of Trustees of the newly formed Illinois College of Optometry. . . . Dr. Alfred Rosenbloom, professor of optometry, Northern Illinois College of Optometry, spoke before the South Carolina Optometric Association on the Turville Infinity Binocular Balance Test: The Technique of Subjective Refraction, and the Relationship Between Aniseikonia and Achievement in Reading. The meeting was held in April in Charleston. . . . The University of the State of New York, Department of Professional Education has announced that the undergraduate professional courses in optometry at the Massachusetts College of Optometry, Boston, and at the Pennsylvania State College of Optometry, Philadelphia, have been approved, making graduates of both of these Colleges eligible for examination by the New York State Board of Examiners in Optometry. . . . Professors Merrill J. Allen and Ingebord Schmidt of the Division of Optometry, Indiana University, were elected to full membership in the society of the Sigma Xi at its May 12 meeting at Bloomington, Indiana.

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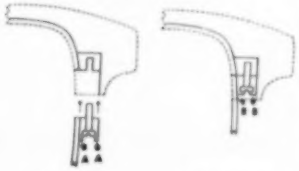

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The American Academy of Optometry has available a limited number of reprints of the following original papers. These monographs, printed with special board covers, will be mailed, postpaid, to professionally interested persons upon receipt of order, and the cost of reprint. Selection should be made by number. American Academy of Optometry, 1502 Foshay Tower, Minneapolis 2, Minn.

- ☐ Monograph No. 103. The Stigmatoscopy Method of Determining the Binocular Status. Robert E. Bannon, F. H. Cooley, Harold M. Fisher and R. T. Textor. 16 p. + cover. Price 35c.
- ☐ Monograph No. 104. Pre-Orthoptic Care of the Very Young Squinter. William Smith. 8 p. + cover. Price 25c.
- ☐ Monograph No. 105. Effects of Uniform and Non-Uniform Surrounds on Foveal Vision. Glenn A. Fry. 16 p. + cover. Price 35c.
- ☐ Monograph No. 106. Relationship of Pre-Optometry College Work to Performance on Optometry College Courses. M. H. Brown and H. W. Hofstetter. 12 p. + cover. Price 30c.
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- ☐ Monograph No. 122. The Magnitude of the Pulfrich Stereophenomenon as a Function of Distance of Observation. Alfred Lit and Aaron Hyman. 20 p. + cover. Price 40c.
- ☐ Monograph No. 123. The Optometrist and First Aid in War Time. John C. Neill. 24 p. + cover. Price 45c.
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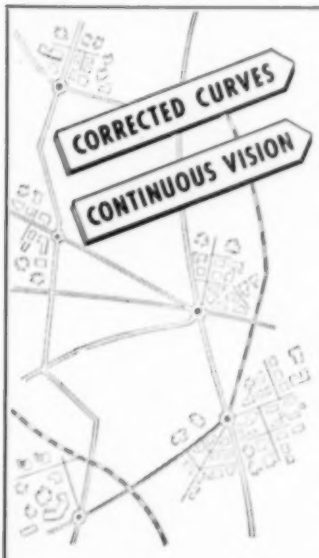

Where do the roads of ophthalmic progress lead?

Scientific progress shows the right roads ahead more clearly with each passing year. This has been particularly true in the ophthalmic field. Those laboratories which have used only the quality products of the progressive manufacturer have found that they benefit and build both themselves and the doctors whom they serve.

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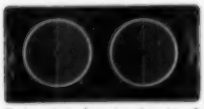

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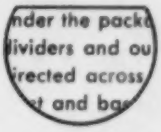

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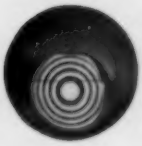

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